GENERAL SCIENCE

HANDBOOK OF ACTIVITIES

CLASSES VI — VIII

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NATIONAL COUNCIL OF EDUCATIONAL
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Foreword

SCIENCE is gaining increasing importance at all levels of education in the country. It is being recognised widely that if our citizens of the future are to contribute in any significant measure to the scientific and technological progress of the country, a very sound basis of science education is necessary. This can be achieved only by strengthening science instruction from the early stages of the child education, the elementary school.

The National Council of Educational Research and Training has therefore placed great emphasis on science instruction in classes I to VIII. Accordingly, the Council prepared in 1963 an all-India syllabus in general science for these classes. This syllabus was developed with the help of several groups of science teachers, teacher educators and science supervisors. It was revised several times before it was finally printed. Without the invaluable help of those who know the educational needs of the youth in India this syallabus could not have been produced.

As the syllabus was written it became clear that it would help teachers if some guide material was provided on how to develop these concepts in the classroom. This handbook of activities is intended to serve this purpose. In this volume we have dealt with the course in classes VI to VIII. A second volume will follow on activities for classes I to V.

The National Council of Educational Research and Training through its Department of Science Education has recently initiated a programme of writing textbooks in general science for these classes. This handbook will, it is hoped, help teachers in developing the concepts through pupil activities using simple materials.

R.N. RAI

February 18, 1964.

Head of the Department of Science Education,
National Institute of Education

We wish to acknowledge with appreciation the help given in the preparation of 'Handbook' by Dr. N.E. Bingham of Teachers College, Columbia University Team in India and Mrs. N.E. Bingham, and officers of the National Institute of Education, Dr. M.C. Pant, Shri N.K. Sanyal, Shri S. Doraiswami, Shri V.N. Wanchoo, Shri I.C. Menon, and Shri K. J. Khurana.

Preface

S[illegible] underlie the writing of this book. One prime objective is to [illegible] to discover and to use the [illegible] of science. This means that pupils [illegible] the opportunity to observe, imagine solutions to problems, to think, to [illegible] conclusions, to operate somewhat like the scientist does in his laboratory. [illegible] be selected, equipment be made available and situations arranged [illegible].

[illegible] is to help pupils gain an understanding of their natural environment. [illegible] should help them to order their lives in keeping with the natural laws. [illegible] many superstitions that stem from ignorance or misconceptions [illegible] physical world about them.

[illegible] is to fit them for a more productive life, one in which they will have [illegible] goods and services, less sickness and a better education, in fact a higher [illegible].

[illegible] is to develop within them an ability to consider the problems of [illegible] their state, and their nation. In this way they may make decisions [illegible] of their fellowmen and thus contribute to the nation as a whole.

[illegible] the *General Science Syllabus* upon which this *Handbook of Activities* [illegible] around thirteen broad areas or units and in each of these areas, the [illegible] concepts were detailed out as declarative statements. In building up [illegible] class, effort was made to take the pupil to sufficient depth in gradual [illegible] him to the recent developments in science as they affect his daily life.

[illegible] *of Activities* has been written so that teachers, both experienced and [illegible] guide pupils towards an understanding of principles through observations, [illegible] and experiments rather than by rote memorizing of the facts of [illegible] cases, background material for the teacher has been provided where [illegible] not be readily available.

[illegible] work in the laboratory is not adequately co-ordinated with the theoretical [illegible] has been organized to attain close co-ordination between theory and [illegible] cases, activities have been suggested to test theories. In other cases [illegible] suggested to enable pupils to develop new theories. Although activities are [illegible] the statement of the major concept and the minor concepts, it is [illegible] the teacher will encourage the pupils to carry out those activities, or that he [illegible] with the help of the pupils before stating the concept which should emerge only [illegible] the activities. In other words, the activities are designed in most cases to enable pupils to arrive at understandings of the concepts presented. It is hoped that pupils

will gain self-confidence as they find dependable answers to their questions through experimentation. After doing the experiments, there should be time allowed for discussion of the implications of the experiments. In a number of instances, several experiments have been suggested, which may lead the pupil to formulation of a new concept.

The publication should be useful in a number of ways. Individual teachers may wish to use it in developing science units. Some experiments can be carried out by mature pupils. Groups of teachers planning for improvement of their science programmes may find it valuable as a basis for discussion. Curriculum committees will find in it a point of view they may wish to consider. Science Club leaders may well utilize some activities to promote science investigations.

Some of the activities are quite simple in execution; some are moderately difficult; some are quite complex while still others may appear too difficult for the majority of pupils in classes VI-VIII. As teachers and pupils in a given group differ greatly in their needs, aptitudes and interests, each teacher must select that which best fits his specific situation. It is hoped that as this material is tried out, teachers and others will send in suggestions to improve future publications in this field.

It is clear that this volume, like the *General Science Syllabus*, could not have been possible without the help of many in the profession who have pioneered in the field. A book such as this borrows much from the work of others. Many experiments and illustrations in General Science have now become a kind of public domain. We acknowledge this help.

If teachers gain some knowledge and inspiration from this book, our labours would have been amply rewarded.

New Delhi
February 19, 1964.

MRS. S. DORAISWAMI
Editor

CONTENTS

UNIT I Air, Water and Weather

CLASS VI

Major Concept 1. Oxygen and moisture present in the air are necessary for rusting.

Concept 1-a (**p. 7**) **:** Oxygen from air combines with the metal to form oxide or rust.

Hang a muslin bag of iron nails or tacks from a cork from the top of a lamp chimney. Stand the chimney in a saucer of water. After a week the water will rise up in the chimney. Iron filings will demonstrate this phenomenon much faster.

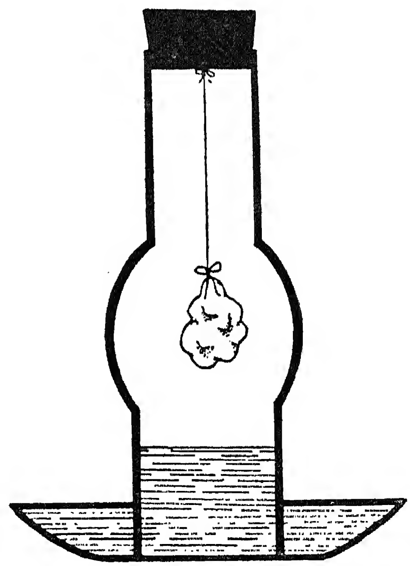

Fig. I. 1. Oxygen is necessary for rusting.

Concept 1-b (**p. 7**) **:** Water makes rusting occur faster.

1. Leave some iron nails (a) in the corner of a shelf; (b) on the window-sill; (c) exposed in the garden for about one week. See which set of nails rusts most rapidly. Account for this.

2. Counterpoise a steel rule or a strip of iron on a knife edge using a brass weight or a stone. Leave it in moist air or on a window sill for a few days and notice the effect of the rust on the longer arm of the lever.

Fig. I. 2. Rusting occurs in moist air.

3. Wet the end of a boiling test tube or a gas jar. Put into it enough iron filings to cover the sides. If steel wool is available, it may be used in place of iron filings and packed at the top of the closed end of the tube or jar. (It is advisable to wash iron filings or steel wool in soap water to remove any grease.) Invert the tube or jar as the case may be, in a dish of water as shown in the figure. Mark the level of the water inside the tube (with a piece of tape or rubber band) and set it aside for observation. Answer these questions: What happens to the iron ? What new substance is formed ? What do you observe about the water level ? How far does the water rise ? Does this tell you something about rusting ? Does it also tell you how much of the air is oxygen ?

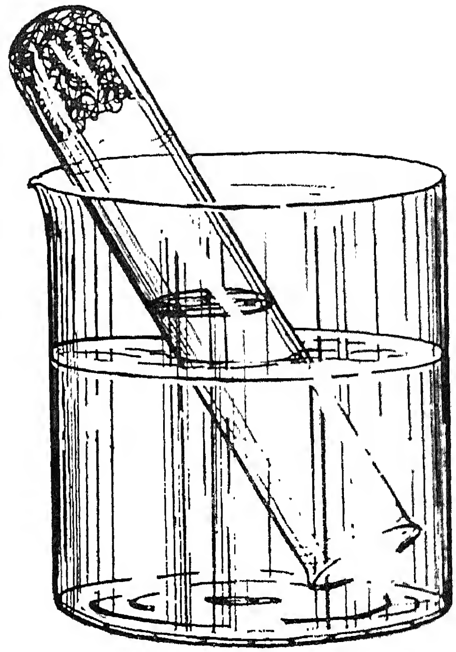

Fig. I.3. Rusting of iron.

Concept 1-c (p. 7): Rusting can be prevented in many ways.

(i) By keeping metals dry.
(ii) By a protective coating of oils or paints.
(iii) By a protective covering with film of another metal like zinc or tin.
(iv) By alloying with other metals.

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1. To demonstrate that rusting can be prevented in many ways, fix an iron rod or nail to a stopper of a dry glass bottle with one portion inside and another portion outside. Observe what happens.

2. Take four similar nails, paint one with grease, another with paint or nail polish, and a third with a film of another metal like zinc or tin. Keep one nail as a control. Place all the nails under identical wet or damp conditions for a few days. Observe what happens. Make a chart of your findings. Which one did you think would rust first ? Did it ? What would you use to prevent rusting ? Set up an experiment of your own trying out different materials. Always keep a control to check your results.

3. Set up an experiment to show how iron and tin compare with regard to rusting. Take your washed iron filings or steel wool and a piece of tin. Place both under similar conditions of air and water. What happens ? Does the tin rust ? What conclusions do you draw ?

4. Set up a similar experiment using iron and an alloy such as bronze which is an alloy of copper, tin and zinc; brass which is an alloy of copper and zinc; German silver (nickel silver) which contains copper, zinc and nickel and no silver. Silver coins are alloys of copper and silver. What conclusions do you draw about alloys and rusting ?

5. Observe the utensils around your home. What kinds do not rust when exposed to air and moisture ?

Major Concept 2. Burning, rusting and respiration are similar processes.

Concept 2 (p. 7)
a. All use oxygen from air.
b. All produce oxides.
c. All produce heat.

Hold a class discussion on how the processes of burning, rusting and respiration are similar, drawing upon pupils' experiences. Bring out how during respiration, oxygen is used and an oxide, carbon dioxide is produced. Illustrate how when substances like a candle burn, oxygen is used and carbon dioxide and water are produced. You can demonstrate the production of heat during respiration by putting flowers or leafbuds in a bottle with a one-holed cork through which passes a thermometer. The bulb of the thremometer should be imbedded in the flowers. Observe the temperature at the beginning of the experiment and after an hour.

To show that heat is produced during rusting, take a clean bottle; wet it slightly and place in it some washed iron filings or steel wool. Fit it with an one-holed cork through which passes a laboratory thermometer. A thermos bottle may give better results. Use a wad of thick cotton or a stopper as a plug through which the thermometer passes. Wrap the bottle in newspaper and place it on several folds of newspaper to prevent loss of heat.

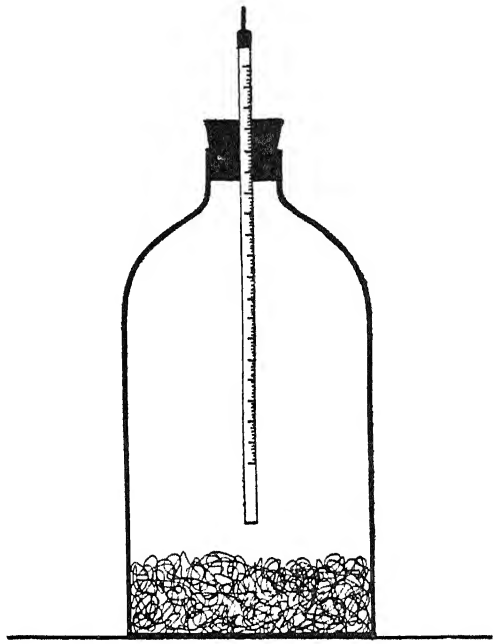


Fig. I.4. Is heat produced by the rusting process ?

Major Concept 3. Some waters are hard and some are soft.

Concept 3-a, b (p. 7):
a. Hard water does not produce lather easily and hence wastes soap.
b. Hardness is due to certain dissolved salts in water.

Dissolved minerals are washed out of the soil by rain water that flows and breaks into streams. Water containing much calcium and magnesium is called *hard*.

1. Does hard water produce lather as easily as soft water ? Secure some hard water from a stream or a tap (if known to be hard) also some soft water such as rain water or distilled water. Make soap solution by dissolving soap shavings or powered soap in a little warm water. (Do not use a detergent.) Place equal amounts of hard and soft water in each of the two bottles. Add soap solution to the soft water with a dropper, a few drops at a time. Shake the bottle well after each addition. Count the number of drops of soap solution needed to produce suds about 1 cm. thick on the top.

Next add the same amount of soap solution to the hard water and shake well for the same length of time. Observe any differences. Continue to

add soap solution to the hard water until you get good suds. How many drops had to be added to make the same amount of suds ?

2. If your water supply is not hard, make some hard water by adding a teaspoon of Epsom salt to a quart of water and shaking it well. Compare this hard water with your soft water supply. Repeat the experiment in (1).

3. Try washing a very soiled cloth in each kind of water to which you have added a similar amount of ordinary soap. Wring the cloths out. Compare them. What results do you get ? Is more soap needed with hard water for making the cloth clean ? How could you improve the hard water. Repeat your experiment after boiling the hard water.

Concept 3-c (p. 7) : Hard water can be softened by several physical and chemical methods.

1. Water can be temporarily or permanently hard. Temporary hardness is due to calcium and magnesium present as bicarbonates, dissolved in the water. You may know calcium carbonate as a common mineral in nature. Limestone, marble, chalk, oyster and snail shells, and pearls are calcium carbonate. These natural carbonates are converted into bicarbonates by atmospheric carbon dioxide dissolved in rain water. In permanent hard water, calcium and magnesium are present as sulphates which are not easy to precipitate out. Permanent hard water can be made by shaking ordinary water with flakes of gypsum. Water is said to be temporarily hard if the hardness can be removed by boiling. The precipitated salt, calcium carbonate, will collect on the walls of the container, removing the water-hardening calcium from the solution. Washing soda (sodium carbonate) will soften permanent hard water. Zeolites, silicates of sodium and aluminium also soften hard water. Sodium aluminiosilicate is one such zeolite used for this purpose. When hard water is run through it, calcium in the water takes the place of the sodium removing the 'hardness'. You can regenerate your zeolite by running salt (sodium chloride) water through it.

2. To investigate that hard water can be softened by chemicals: (a) Add some washing soda (sodium carbonate) to a sample of permanent hard water. Now try making suds with soap solution. You will observe that water has been softened. (b) Add some borax (sodium pyro-borate) to a sample of permanent hard water and test to see if it has been softened.

3. Boil hard water in a tea kettle and condense the steam that comes out of the spout by holding a clean cold slate against it.

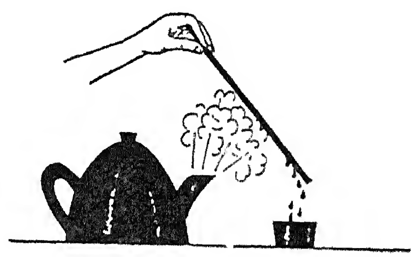


Fig. I. 5. Distillation of hard water.

Collect 50 ml. of condensed water in a clean glass vessel. Test the distilled water with soap solution and find out if distillation has removed the hardness.

4. Sometimes the city water supplies are hard and have to be softened by adding chemicals. Check on your own water supply. Is it hard or soft ? Is anything being done to improve it ?

Major Concept 1. Air surrounds the earth like a giant blanket. It is in layers. These layers extend upwards for hundreds of miles.

Concept 1-a (p. 7) : Air is all around us.

1. Let's trap some air. Take a plastic bag and put your hand inside. Fluff up the bag. Or open the end and scoop some air in. Twist the open end and close it. Hold it tightly. Poke the bag. Press it down on a table. You know there is something in it. You have trapped air. Now let the air escape. What can you do with air ?

Fig. I.6. Air occupies space.

2. Plan a way to teach a young child that air is all around him. Could you have the child try to trap air with the plastic bag in a variety ot places ? What other ways do you suggest ?

Concept 1-b (p. 7) : The atmosphere is in layers and these layers have definite characteristics.

With the present growing interest in space, there should be active interest in the intervening medium, the earth's atmosphere. Discuss the troposphere, the stratosphere and the ionosphere, their relative thickness and characteristics.

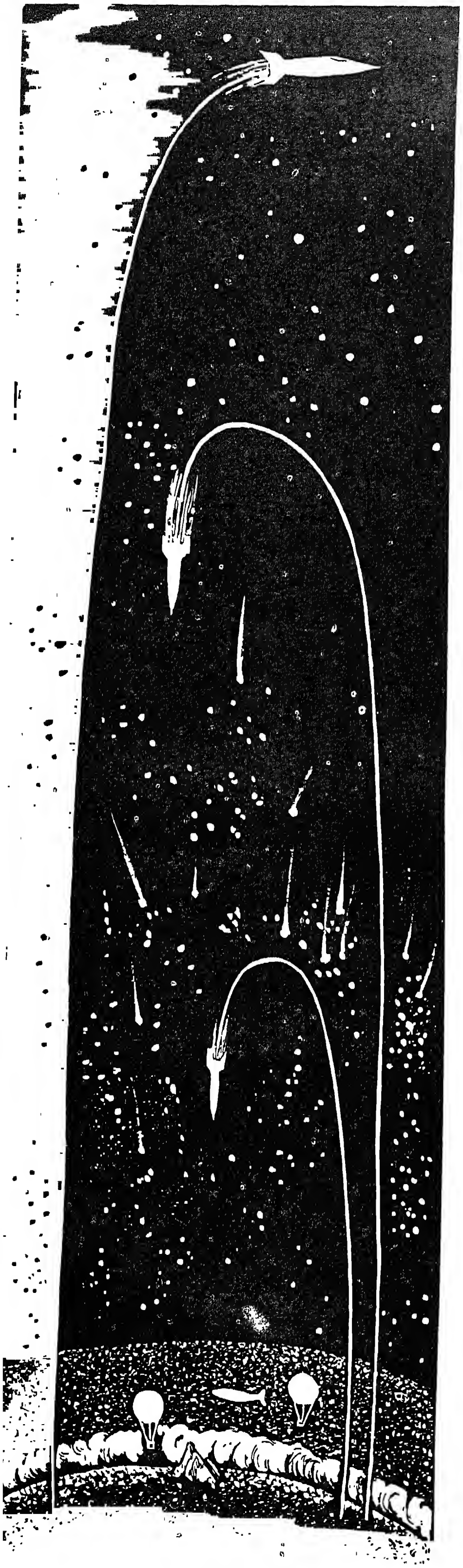


Fig. I-7. Layers in the atmosphere.

1. Make a large scale blackboard or soft-board chart of the earth's surface and the atmosphere above it. As each layer is described, place symbols for items in each layer on the drawing. The troposphere is most important in the study of weather. You may say that the ionosphere is roughly 7 times the stratosphere. Your drawing can be on a scale of 10 miles to an inch. The troposphere is the layer closest to the earth. This is the layer in which all plants and animals live. You really live at the bottom of this great blanket of air. Winds, clouds, humidity and various kinds of storms occur in the troposphere. The air moves about freely. It settles in low areas and ascends by convection currents to a considerable height. Near the equator the troposphere is about ten miles thick, while at the poles it is only four to five miles thick. The stratosphere extends some 50-60 miles above the troposphere. Here the air is too thin for breathing and there are great temperature changes. Research goes on continuously on what is above the stratosphere. The name ionosphere has been given to this region. Scientists know that there is practically no air and no wind at this altitude. They have found this to be an electrified region, a region containing ions of which you will learn more. Check a recent encyclopaedia for the height of the ionosphere.

2. Read newspaper and science magazine reports of new developments in the ionosphere and beyond. Keep a scrap book in your classroom to record all this new knowledge.

3. Study the history of the measurement of the atmosphere. You will want to learn of Piccard, his brother and their famous balloon ascents. What method are being used today to study the atmosphere ?

Major Concept 2. The air is composed mostly of gases, which are compressible, have weight and exert pressure.

Concept 2-a (p. 7) : Air is compressible.

1. Secure a bicycle pump and place your thumb over the end of the outlet tube. Next push the piston in forcibly and quickly let it go. What happens ?

2. Fill a balloon, a football bladder, or a cycle tube with air. You are compressing air and pushing the air molecules closer together.

Concept 2-b (p. 7) : Air has weight.

Does air have weight ? Balance an inflated balloon with some paper clips on an improvised balance scale.

A balance can be very useful in experimenting. Take a metre stick. Bore three holes, one at each end and one in the middle. Bore the hole in the middle slightly higher than the midpoint. Pass a string through the middle hole and suspend it from a nail or hook. Suspend the inflated balloon at one end. Balance it with paper clips at the other end. Now prick the balloon. Observe the balance. You can also use two inflated football bladders, deflating one to observe the difference in weight. How else can you demonstrate that air has weight ?

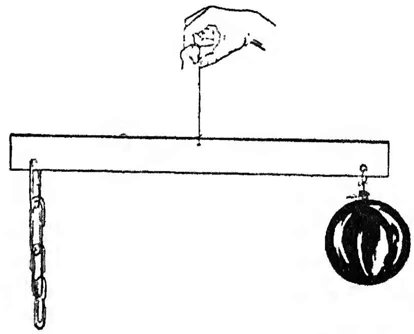


Fig. I.8. Air has weight.

Concept 2-c (p. 7) : Air exerts pressure; the pressure is due to the weight of the air.

1. Can you show that air exerts pressure ? Float a cork on water in an aquarium or large glass dish. Hold a glass tumbler over the cork with the rim touching the water. Push the tumbler straight down. Observe that the cork stays fairly near the rim of the tumbler, no matter how far down you push. Does air exert pressure on the water ?

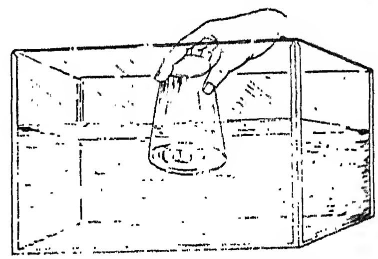


Fig. I.9. Air exerts pressure.

2. Air not only presses downwards, but also presses upwards and sideways. Many of you may have tried this experiment. Fill a drinking glass to the brim with water. Place a piece of cardboard or firm plastic (such as a cover of a jar) over the rim of the glass. Invert the glass, keeping the cardboard in place with the hand. Then, take away the hand holding the cover. What holds the cardboard or plastic without falling ? Air pushes upwards.

Fig. I.10. Air exerts pressure upwards.

If you are very careful and are doing this over a sink, try turning the glass sideways. Does the cardboard stay without falling ?

Try this experiment and draw your conclusions. Wet a handkerchief. Fasten it by means of a rubber band over a tumbler full of water. Over a sink invert the tumbler quickly. What holds the water in the tumbler ?

Fig. I.11. What holds the water in the tumbler ?

3. Take a funnel. Attach a rubber or plastic tube to the stem of the funnel. Float a cork on the water in an aquarium tank as in the first experiment on air pressure. Place the large end of the funnel over the cork and push the funnel to the bottom. Now blow gently through the tube at the other end of the funnel.

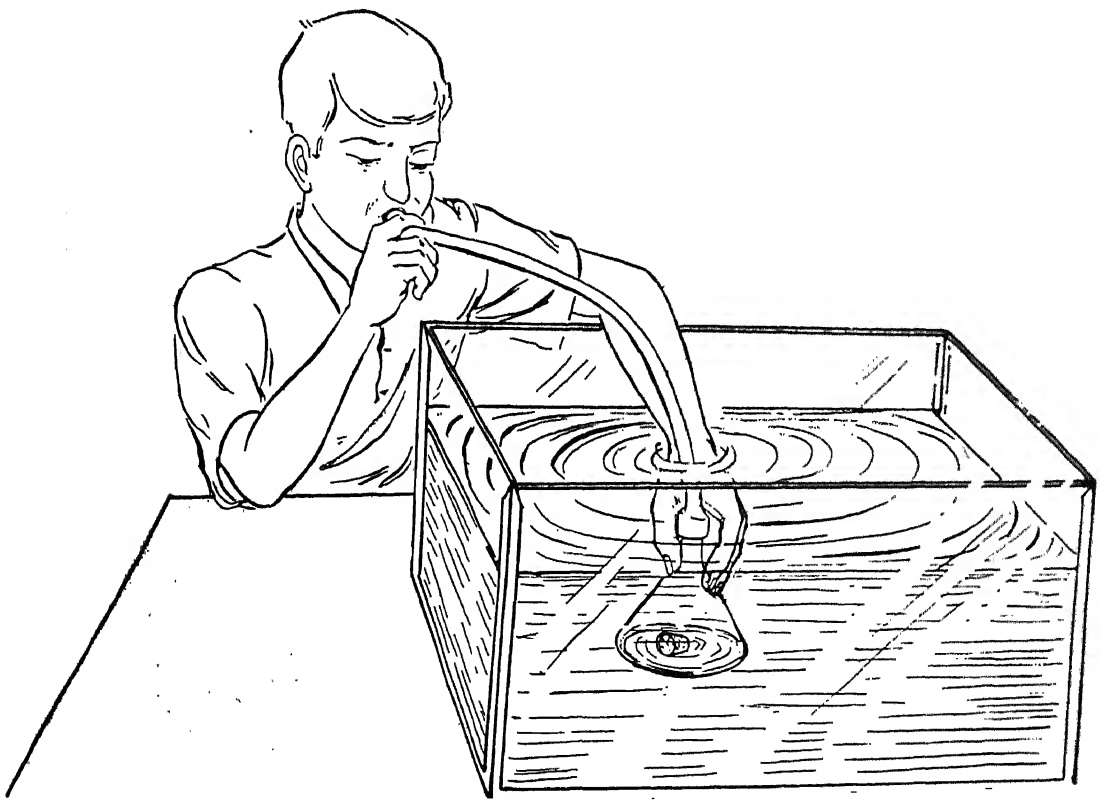


Fig. I.12. Air exerts pressure in all directions.

Does the cork float lower ? When there is no more water left in the funnel, where is the cork ?

Can you think of how this principle is used when men have to work deep in water such as in the sea or in rivers ? Look up about the use of the caisson.

Is the air pressure equal outside and inside the plungers ? When was the pressure inside the plungers reduced ?

5. Read about Otto Von Guericke's famous experiment with air pressure in Magdeburg, Germany. You may find the reference under Magdeburg Hemispheres. Tell the story to your class. Get two rubber sink stoppers; wet the bottoms and press them together. Now try to pull them apart. Can you demonstrate what Von Guericke discovered ? If you wish to keep these stoppers for demonstrations, make a horizontal hole through the centre knob and insert a metal ring or stout string for a handle. This makes them easier to operate.

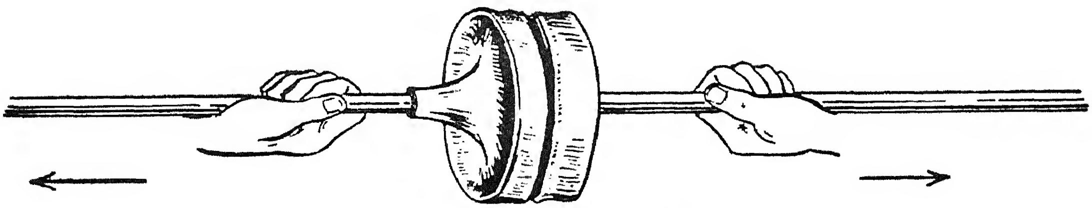


Fig. I. 13. What holds these together ?

4. Do the following experiment and see if the questions at the end can be answered.

Wet the rubber cap of a sink plunger (plumber's force cup), or a dart of a toy pistol and press it against the floor.

Try to pull it free. Pick up a small object by pressing the plunger against it and then by lifting it upwards by the handle. Press the rubber caps of two plungers together and try to pull them apart.

Concept 2-d (p. 8) : Air becomes progressively less dense with an increase in altitude.

Those who have climbed mountains or lived at high altitudes can tell how they feel as they go higher. The air becomes thinner and thinner as you move higher and higher from the sea level. Draw a picture of how you think the molecules in the various gases that make up the air, look close to the earth. Now picture the molecules in the various gases that make up the air on top of Mount Everest. Five miles up on Mount Everest, the air pressure is only about one half of what it is at sea level. What precautions do climbers take ? Imagine the distribution of gas molecules in the upper region of the stratosphere. (Stratosphere is some sixty miles above the troposphere.)

Major Concept 3. Air pressure is measured by a barometer.

Concept 3-a (p. 8) : Air pressure may be measured by various home-made barometers.

1. Stretch a piece of rubber over the large end of a funnel. Remove some of the air from the funnel by sucking at the narrow end. Quickly place your finger over the narrow end and close it. Observe how the rubber sheet gets drawn in. Explain this.

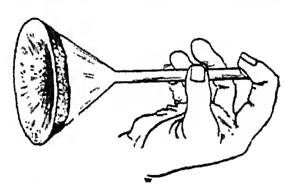


Fig. I. 14. Changes in air pressure.

2. Make a barometer for your home laboratory or your classroom. The word 'barometer' comes from two Greek words, *baros* means weight or pressure, and *meter* means to measure.

The atmospheric pressure varies with altitude, temperature of the air, and the amount of moisture in the air, and so a barometer is a handy instrument to have.

Fill a bottle partly with water and invert it in a saucer containing water so that the neck is under water. Stick a paper label on one side to indicate the rise and fall of water level in the bottle.

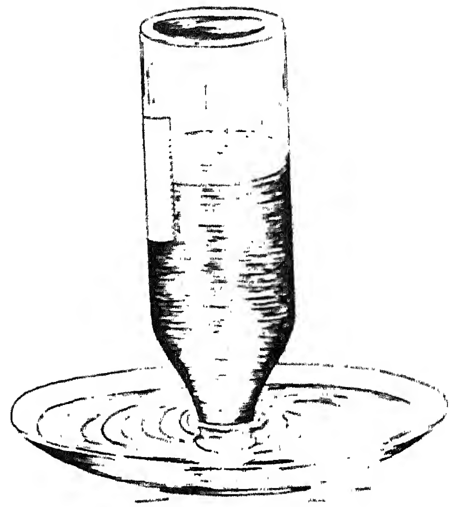


Fig. I.15. Water barometer.

3. Stretch a sheet of rubber over the mouth of a small glass jar or wide mouth bottle. Wind a thread over the neck of the bottle tightly to secure the rubber. With a little household cement or tape seal the edges of the rubber, after trimming off the edges. Cut a thin circle from the end of a cork and glue it to the centre of the rubber. Then glue a long broom splint on the cork to serve as a pointer. Make a fulcrum by sticking a match stick on the shoulder of the bottle with sealing wax (see Fig. I.16). Fix an arc cut from a cardboard to serve as a scale. You now have an aneroid barometer.

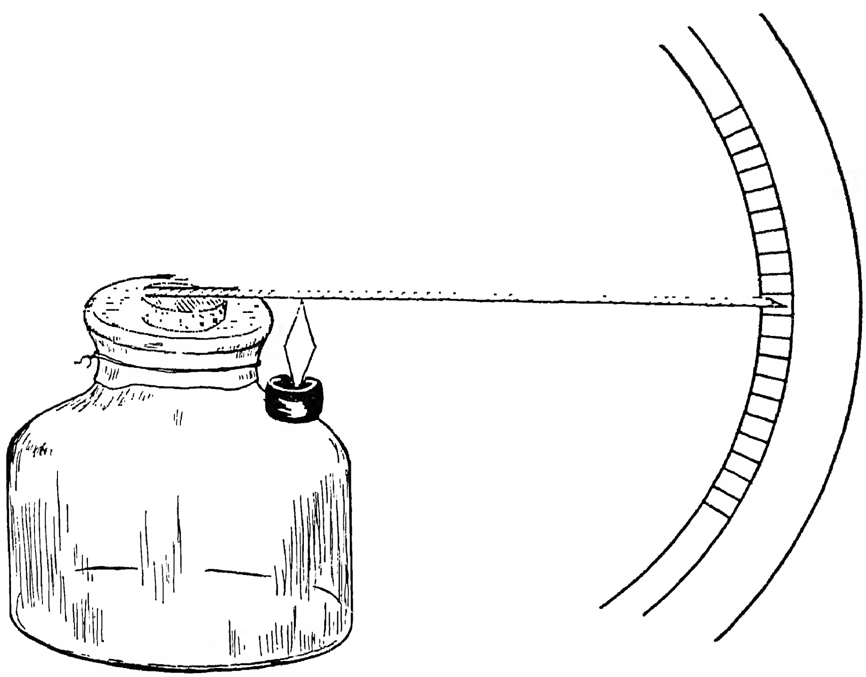


Fig. I.16. An improvised aneroid barometer.

5. Make your air barometer when the air pressure is high for your region. If your school is less than 500 feet above sea level, 30 inches is considered a high pressure reading. If the school is at a higher altitude, find out from the nearest weather station or a college science laboratory about the high pressure reading.

Concept 3-b (p. 8): Air pressure may be measured more accurately by a mercury barometer.

1. Read about Toricelli's discovery in 1640. You will recall how a 50 feet well was dug and fitted with a pump and how water would rise no farther than 34 feet when the pump was operating. Galileo was too old at this time to experiment and find a solution to this problem, but his young assistant, Toricelli solved it. He knew water could be made to go 34 feet up a pipe from which air had been removed. He reasoned that if the atmosphere could support 34 feet of water, it should be able to support about 2½ feet of mercury which is 13.6 times as heavy as an equal volume of water. So he thought a column of mercury 1/13.6 as high as the water column or 30 inches could be supported. Was he correct ? Air pressure is expressed in inches of the mercury column that it supports. The Weather Bureaus today use millibars to express air pressure. Thirty inches equal 1016 millibars. What should the multiplier be if you wish to change inches of air pressure to millibars ?

2. How can atmospheric pressure be measured ?

Secure a glass tube about three feet long and closed at one end. With the aid of a medicine dropper, carefully fill the tube with mercury. Tap the tube gently to let the air escape. Take a shallow dish and fill it almost three-fourths with mercury. Now place your thumb or first finger tightly over the open end of the tube, invert it and place the open end well under the mercury in the dish. Remove the finger and clamp the tube in a vertical position. Mount a metre stick with the zero end even with the surface of the mercury in the dish.

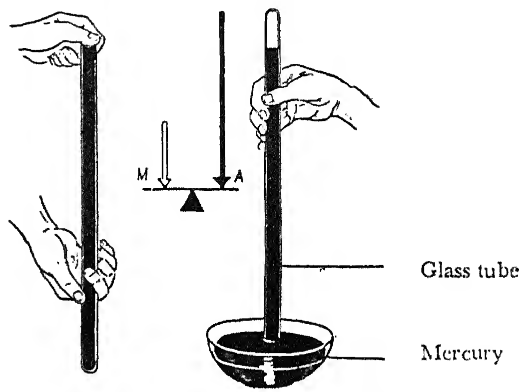


Fig. I.17. A mercury barometer.
(M=mercury; A=air)

What happens to the mercury in the tube ? What is in the space above the mercury? How high is the mercury column?

How can this column of mercury be used to measure air pressure?

What are the advantages and disadvantages of mercury barometers?

If you cannot obtain mercury, perhaps you can observe a barometer at a high school science laboratory nearby.

The mercury barometer that we use today is just an improvement on Toricelli's over 300 years ago. Look at one to note the improvements.

Concept 3-c (p. 8): Air pressure may be measured by aneroid barometer.

1. The aneroid barometer is much used today. Aneroid comes from two words, meaning *without liquid.* It contains no liquid, and, therefore, it is sometimes called a dry barometer.

It is a very delicate instrument. Obtain an aneroid barometer from a physicist or a high school science laboratory and observe the metallic box with a thin slightly curved cover. As the air has been partially removed from the metal box, the slightest change in outside pressure will affect the curvature of the cover. A series of levers connects the inside of the cover to a needle on the face of the box where the pressures are shown. What really causes the needle to move? If you can keep the aneroid barometer for a week, record the readings and make a chart of this information. Was the reading high on a clear cold day? Was the reading low on a warm, moist, cloudy, or rainy day?

2. Read how the aviator's altimeter works and how it tells the altitude of a plane to the pilot during flight.

3. If you visit a weather station, you may see a *barograph* which operates like an aneroid barometer, but indicates variations in pressure by the writing of a continuous record on a revolving drum.

Major Concept 4. The atmosphere may be considered a giant heat engine that distributes the energy which falls unequally upon the earth's surface by means of winds.

Concept 4-a (p. 8): Hot air weighs less than cold air.

1. Describe what you mean by the earth's atmosphere. You are spending your life at the bottom of the atmosphere. It seems to be a comfortable place with oxygen to breathe, enough moisture, and a temperature that you can stand. The atmosphere must be a protective blanket, shielding you from too much sun and holding for you the things you need. Find out more by reading about the earth's atmosphere. Think of a great pile of blankets. How hard is it to pull out a blanket from the bottom of this pile? How easy is it to do so from the top? You are at the bottom, where the earth atmosphere is most dense.

2. How do warm and cold air compare? Stretch a balloon over a narrow mouthed bottle. Place the bottle in a pan of hot water or place the pan over a source of heat. What happens to the balloon? (It inflates). Remove the bottle from the heat and observe.

What happens to the air in the bottle when it is heated? (The molecules of air move about faster and the air takes up more space: it expands.) Describe the cooling effect. (The air takes up less space and so goes out of the balloon.)

3. Blow a small amount of air in a balloon and tie the neck with string. Place the balloon in a glass jar placed in a pan of water. Heat the

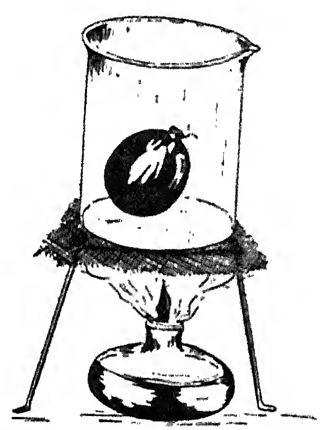


Fig. I. 18. Air expands when heated.

pan slowly. Do you see the balloon getting larger as the air inside expands? Remove the pan from the stove and cool rapidly with ice cubes if possible. Does the balloon get smaller? State your conclusions.

4. Get a chilled empty soda bottle. Grease the rim of the neck and place a coin on it. Warm your hands by rubbing them quickly together.

Hold the bottle between your warm hands. What do you expect to happen to the coin ? Is this consistent with what you believe about cold and warm air ? Air expands when it is heated. Air contracts when it is cooled. Heating air and cooling it cause air to move.

5. Punch a hole at each end of a shoe box. Place a cardboard partition inside the box. Fix a small electric light to a cord. Pass the cord through one compartment so that the lighted bulb is inside the compartment, and replace the box cover. After several minutes, take the temperature of each side by passing a thermometer down through the holes in the box top. Now turn off the light. Remove the cardboard partition. Wait for two minutes, then take the temperatures again at each end of the box. What has happened to the hot and cool air ? (They have mixed and the temperatures are alike in both parts.)

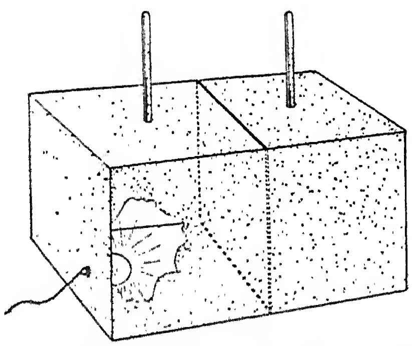


Fig. I.19. Do warm and cold air mix ?

6. You can weigh hot and cold air but it is difficult unless you have heat proof containers. Flasks used in science laboratories can serve very well. Set up an experiment to see how a flask of warm and cold air compare. Use the homemade balance, which you made with a stick. (p. 7) Hang it on a ring stand or an improvised stand.

If you cannot get flasks, you may try two inverted bags on your balance.

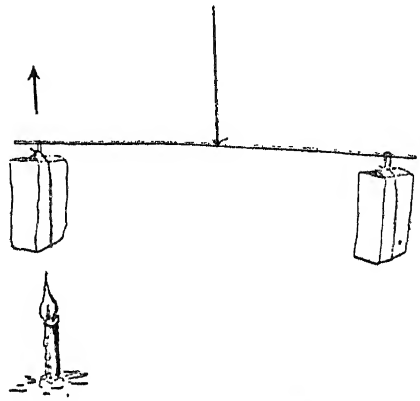


Fig. I.20. Hot air weighs less than cold air.

It is better to use an electric bulb for the source of heat. Be very careful if a candle is used. Hold the source of heat beneath the opening of one bag. When the air is warmed, it expands, moves out, leaving less air in the bag. The air now left weighs less than that in the unheated bag. (The bags should be large and the wooden stick light and long).

Concept 4-b (p. 8): Heat energy makes winds blow. Winds carry heat by convection currents.

1. Take a globe. Describe the heating of the air at the equator and at the poles. Knowing what you do of hot and cold air, what do you expect to happen to the hot air over the equator ? To the cold air at the poles ? You expect the lighter hotter air to be pushed up by the colder heavier air. Some of this does happen, but weather is not this simple because the turning of the earth makes a difference.

2. Make a convection box. It is a valuable piece of equipment for your laboratory. There are several ways to make this. You will think of others. By using this convection box you will be able to observe that movements of air (winds) are caused by unequal heating of the air.

Set up the convection box, making two openings on the top of a cardboard box, one towards each end. Place a glass chimney over each opening. Place a candle under one of the chimneys.

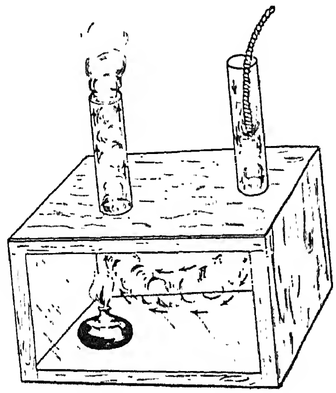


Fig. I.21. Convection box.

Light the candle. Produce smoke by igniting some damp paper. A burning incense stick can also be used. Hold the smoking object above the chimney away from the candle. Notice that smoke is carried down the chimney, across the box, and up the other chimney. A wind current is set up in the box with the warm air rising over the candle and the cool air coming in through the other chimney. Thus a wind is set up by unequal heating—much as local winds are set up on earth.

If lamp chimneys are not available and you have a way to cut glass, you can cut the bottom of any straight sided glass jar and use them for chimneys.

Major Concept 5. Air pressure is used in many ways in daily life.

Concept 5-a (p. 8): Air pressure is used as a cushion.

Operate your bicycle pump. Hold your finger over the air outlet and note the force exerted by the compressed air.

Ride a cycle with the tyres fully inflated. Then release some air to make the tyres limp. Now ride again and observe the difference. Find out how air cushioning helps in landing an aeroplane.

Concept 5-b (p. 8): Air pressure is used to lift water.

Can air lift things ?

1. Set up a siphon arrangement and explain how the pressure of the atmosphere helps.

2. Put several heavy books on top of a hot water bag or a balloon which you have placed on a table. Blow hard into the bag or the balloon.

Fig. I. 22. **Air can lift things.**

Can you lift the books easily ? The molecules of air are being pressed together. They exert pressure on the sides of the balloon. You can put this pressure to work.

3. Try this with an old teacup. Place a balloon in the cup with the lower edge resting on the bottom of the cup. Blow up the balloon, close its mouth and lift it by its neck. Repeat this using a tumbler.

Fig. I. 23. **Can air do work?**

4. Observe a wash bottle and explain how it works.

Concept 5-c (p. 8): Air pressure is used in judging altitude.

1. The altimeter is really an aneroid barometer in which instead of pressure, altitude (above sea level) is marked on the dial.

There is a metal can from which air has been partially removed. Changes in atmospheric pressure cause the can to inflate or deflate. One end of the can is fixed. The movement of the other end is carried by a system of levers to an indicator which rotates and marks the elevation on the dial.

2. A model of an altimeter that works on the same principle can be made as follows:

Take a wide mouthed jam jar with a metal screw cap. Pierce a hole in the metal cap to pass through it a foot of rubber tubing.

Cut a piece of balloon and stretch it over a glass vial (a used injection vial). Hold it in place with a rubber band. By means of glue or adhesive tape fix a match stick or a piece of broom stick on the rubber top. Put this vial inside the jar. Close the screw cap and make all joints air tight by using molten wax.

Now suck air through the tube and observe what happens. Close the tube by a pinch cock. Release the pinched tube and observe the movements of the indicator.

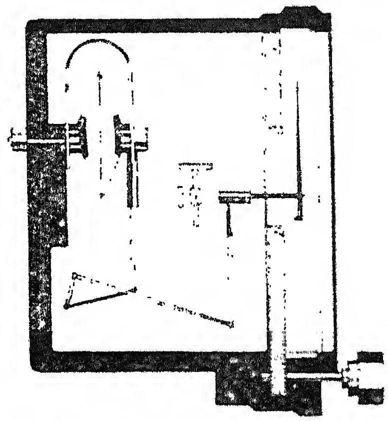


Fig. I 24a. An altimeter.

Fig. I.24b. Model of an altimeter.

Concept 5-d (p. 8): Air pumps are used to move things.

1. When air is pushed into a container that cannot expand, the air is said to be compressed. When compressed air is freed, it can do work. The air-lift used in garages to lift cars works on this principle.

Find out how air-brakes work on trains, buses, and many trucks. What other examples of the use of compressed air can you discover ?

2. How does water rise in a lift pump ? Take a medicine dropper or syringe. Insert the end of the dropper in a glass of water. Press the bulb and then allow the bulb to expand. Explain what you did in terms of air and water. Or fill a fountain pen ink filler and explain how it works. What is in the dropper or filler when you press the bulb ?

3. Study the accompanying diagram.

Try to explain the steps in the action of a lift pump. Next time you use one, try to visualize what part air pressure plays in making the pump work.

4. Make a model of a lift pump. Use a straight sided lamp chimney or plastic tube as a pump cylinder. Fix a two-holed cork or stopper for a piston. Adjust its size with string if it is too small or file it if it is too large. Through one hole fix a metal or wooden rod for a piston. Cover the second hole on top of the stopper with a little flap of rubber or leather from an old shoe. Fix another stopper carrying a glass tube on the lower end of the chimney. Over the hole of the stopper put another valve of leather or rubber. This is the foot valve. Take water in a jar. Watch the valves operate. How does air pressure make the lift pump work ?

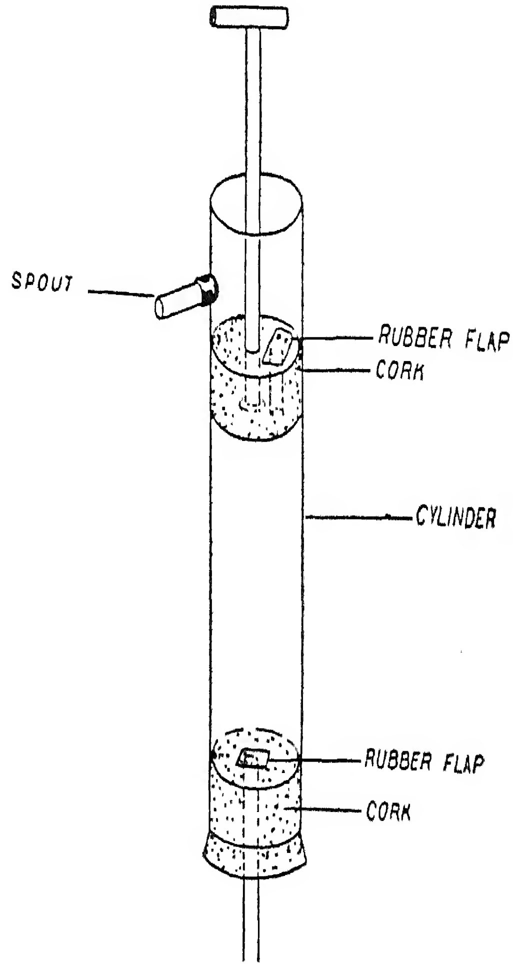


Fig. I.25. A model lift pump.

Major Concept 1. Temperature, pressure and humidity are important factors in weather.

Concept 1-a (p.8): Human beings can work efficiently and comfortably when the temperature of the surroundings is 24°C.

1. Describe how you feel when the temperature is higher than 24° C. Why must you be careful to take plenty of liquids and some salt when the temperatures are high?

2. Find out all you can about air conditioning.

Concept 1-b (p.8): Temperature is measured by thermometers, pressure by barometers, and humidity by hygrometers.

1. Keep track of temperatures as noted in the newspapers. How far can you trust your senses in noting weather changes? Can you feel water (humidity) in the air? Can you tell a small change in temperature? Would all people react the same to these changes? It is a good plan to have some instruments to guide your observations.

2. The word thermometer comes from *therm* meaning 'heat' and *meter* meaning 'to measure'. Do you have a thermometer in your room? Read it and keep a record of temperatures. Take temperatures at different places, on the open playground, on the grass under a tree, on all the four sides of your building, near the ceiling and near the floor of your room. What other places do you suggest? Account for the differences. Find out how thermometers are made. In some earlier experiments you have seen that liquids expand when heated and contract when cooled. Relate this principle to the thermometer.

Fit a medicine bottle or ink bottle with a cork through which passes a long glass tube. Fill the bottle with coloured water till it rises about a third of the length in the glass tube. With a medicine dropper, add a drop of vegetable oil in the tube so that it floats on the water level. Seal the edges of the cork with a little molten paraffin wax. Fix a paper scale on the glass tube as shown in the figure.

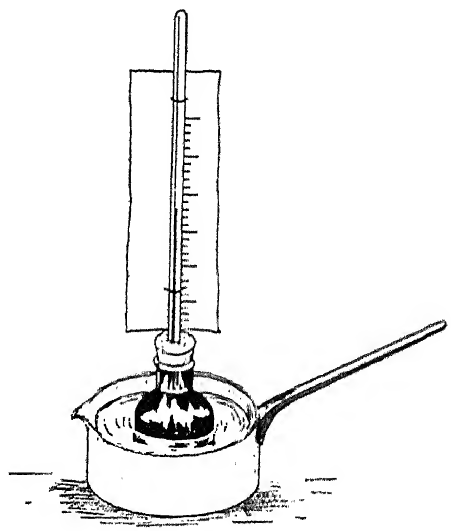


Fig. I.26. A water thermometer.

Place the bottle in a pan of hot water. Mark the level of the water. Now place it in ice cold water and mark the level of water in the tube.

With the help of a standard thermometer the paper scale can be calibrated.

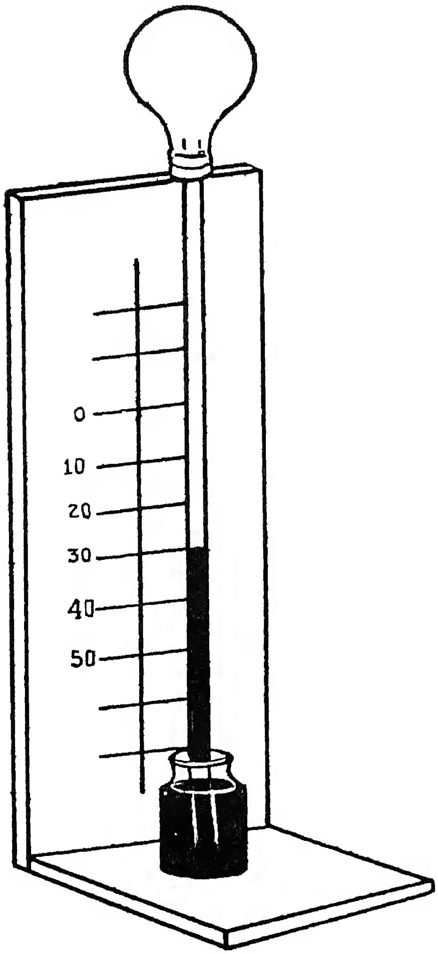


Fig. I.27. Air thermometer.

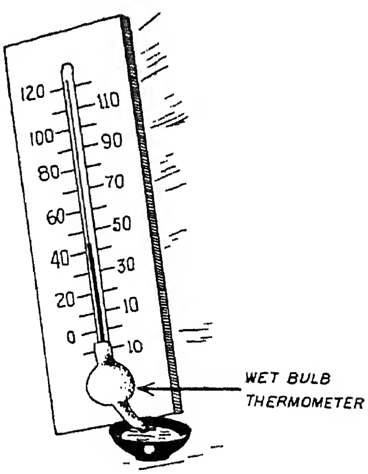


Fig. I. 28. Wet-bulb thermometer.

To make an air thermometer cut the neck of a fused electric bulb. Fix a one-holed rubber stopper on the neck of the bulb. Pass a glass tube through the hole. Use molten wax from a candle to make the stopper air-tight at the joint. Support the bulb on a wooden stand on which a strip of paper has been pasted to serve as a scale. Place the lower end of the glass tube in a small bottle containing coloured water. A few drops of red ink added to water will give you this.

Warm the bulb slightly so as to drive out the air. When the bulb cools to room temperature, the coloured water will rise to about half way up the tube. Stand the thermometer in a room for several hours. With the help of a standard thermometer, make a line on the paper at the level of the water and note the temperature against the line. Next move the air thermometer to a warm place and let it stand for an hour with the other thermometer near the bulb. Mark the water level and the temperature. Move again to a cool place and similarly mark the temperature. Divide the space into suitable divisions and mark off the temperatures. This is your home-made air thermometer.

The air thermometer will illustrate the greater expansion and contraction of gases with changes in temperatures as contrasted with liquids.

3. Read the history behind the commonly used scales of Fahrenheit and Centigrade. You will enjoy discovering how the freezing and boiling points were established. You will also find out that Galileo was the first to devise a thermometer in 1593.

4. How can you find out about the water vapour in the air? A hygrometer is used for this. You have no doubt guessed that *hygro* relates to moisture and this instrument measures moisture.

To make a hygrometer, secure two inexpensive Fahrenheit thermometers and check the readings on them several times a day for several days to see that they agree. Attach the two thermometers to a piece of board.

Fasten a small bottle near one of the thermometers. Fasten a wick made from linen cloth, or a shoe-lace around the exposed bulb and let it dip into the bottle. The bottle should be filled with rain water. This device will help you measure the relative amount of water vapour in

the air at any given time. Hang the instrument where it has free access to air. Fan the wet bulb until the temperature will go no lower. Make a reading of first the wet bulb and then of the dry bulb. Subtract the wet bulb reading from the dry bulb reading and then refer to the humidity table. To use the table, locate the dry bulb reading in the left hand column. Now move across the column till you come to the top figure showing the difference between wet and dry thermometers.

The figure where the two columns cross shows the percentage of relative humidity.

TABLE I-1 HUMIDITY TABLE

DIFFERENCE BETWEEN DRY AND WET BULB READINGS

	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°
100	96	93	89	86	83	80	77	73	70	68	65	62	59	56
98	96	93	89	86	83	79	76	73	70	67	64	61	58	56
96	96	93	89	86	82	79	76	73	69	66	63	61	58	55
94	96	93	89	85	82	79	75	72	69	66	63	60	57	54
92	96	92	89	85	82	78	75	72	68	65	62	59	56	53
90	96	92	89	85	81	78	74	71	68	65	61	58	55	52
88	96	92	88	85	81	77	74	70	67	64	61	57	54	51
86	96	92	88	84	81	77	73	70	66	63	60	57	53	50
84	96	92	88	84	80	76	73	69	66	62	59	56	52	49
82	96	92	88	84	80	76	72	69	65	61	58	55	51	48
80	96	91	87	83	79	75	72	68	64	61	57	54	50	47
78	96	91	87	83	79	75	71	67	63	60	56	53	49	46
76	96	91	87	82	78	74	70	66	62	59	55	51	48	44
74	95	91	86	82	78	74	69	65	61	58	54	50	47	43
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42
70	95	90	86	81	77	72	68	64	59	55	51	48	44	40
68	95	90	85	80	76	71	67	62	58	54	50	46	42	38
66	95	90	85	80	75	71	66	61	57	53	48	44	40	36
64	95	90	84	79	74	70	65	60	56	51	47	43	38	34
62	94	89	84	79	74	69	64	59	54	50	45	41	36	32
60	94	89	83	78	73	68	63	58	53	48	43	39	34	30
58	94	88	83	77	72	66	61	56	51	46	41	37	32	27
56	94	88	82	76	71	65	60	55	50	44	39	34	30	25
54	94	88	82	76	70	64	59	53	48	42	37	32	27	22
52	94	87	81	75	69	63	57	51	46	40	35	29	24	19
50	93	87	80	74	67	61	55	49	43	38	32	27	21	16
48	93	86	79	73	66	60	54	47	41	35	29	23	18	12
46	93	86	79	72	65	58	52	45	39	32	26	20	14	8
44	93	85	78	71	63	56	49	34	36	30	23	16	10	4
42	92	85	77	69	62	55	47	40	33	26	19	12	5	0
40	92	83	75	68	60	52	45	37	29	22	15	7	0	0

Colour changes caused by varying moisture content of air can be shown by soaking strips of white cloth in a solution of 10 grams of cobalt chloride in 100 grams of water. Remove the strips and dry them. Test them by placing them outdoors and indoors and check on the humidity. Does pink colour indicate more moisture ?

5. Review what you learnt about barometers in class VII. Have someone make an air barometer for your classroom and someone make a liquid barometer.

Record the reading of the barometer each day at the same time for several days. Make a graph of these data. So also you can record changes in pressure. Discuss the kinds of barometers, such as mercury and aneroid. Look up more information about them.

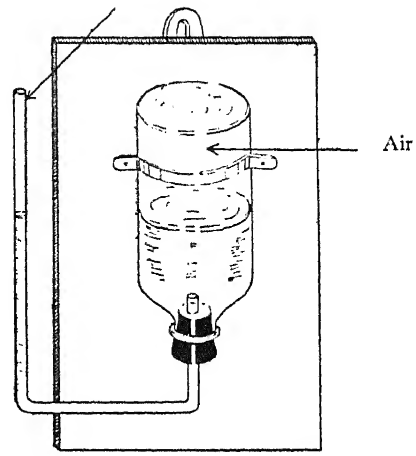


Fig. I-29. Water barometer.

Concept 1-c (p. 8) : Pressure and temperature decrease with altitudes.

1. Have you ever felt a change inside your ears driving in a car from a high hill down to the valley ? People who travel in aeroplanes plug their ears with cotton wool. Why ? Pile some twenty to thirty books one on top of the other. Try to pull out the lowest book and one from the middle. Which needs greater force to pull out ?

2. Discuss living under a blanket of air or perhaps visualize a column of air. What will be the top like as far as pressure is concerned ? Borrow an aneroid barometer, if possible. You will find that for each mi limetre the pressure decreases, you have made a gain in altitude of 11 metres.

Concept 1-d (p. 8): Other instruments are also used in recording and predicting the weather; a radiation gauge measures hours of sunshine; a rain gauge, centimeters of rainfall; an anemometer, the velocity of the wind.

1. Is the weather often just the same for several days ? Is it perhaps a hot spell, a rainy spell or a spell of cold or foggy weather ? Usually winds change before such a stretch of like weather. A wind may shift direction. Gusty winds may blow. Calm air may start moving. One of the oldest weather instruments is a wind vane or so called weather vane. You can see why it was commonly called weather vane. Observe some wind vanes.

2. A simple wind vane can be made by inserting a feather in a straw, passing a pin through the straw into a pencil eraser. Make another working model of a weather vane. Make the pointer end small. To get ease in turning, mount a darning needle or slim nail on wood and place over it a glass tube or glass portion of an eye dropper with the small end sealed.

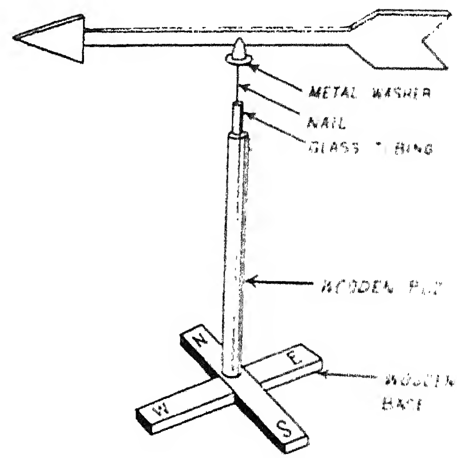


Fig. I.30. Wind vane.

3. Make a working model of a wind sock. Have you seen a wind sock in use at an airport ? In the model sew a nylon stocking or similar material in the shape of a sock to a wire coat hanger.

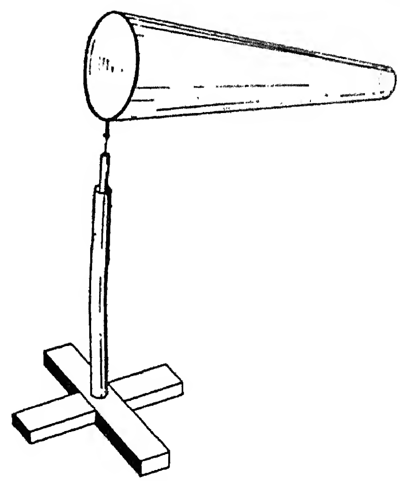


Fig. I.31. Wind sock.

4. How fast does the wind blow ? Make a model anemometer. Make your pivot with a nail or big needle slipped into a glass tube with sealed end. Calibrate your anemometer by marking one cup 'X' and get a friend to take you for a slow ride in his car while you match his speedometer with the number of turns of your anemometer. Make a scale from this.

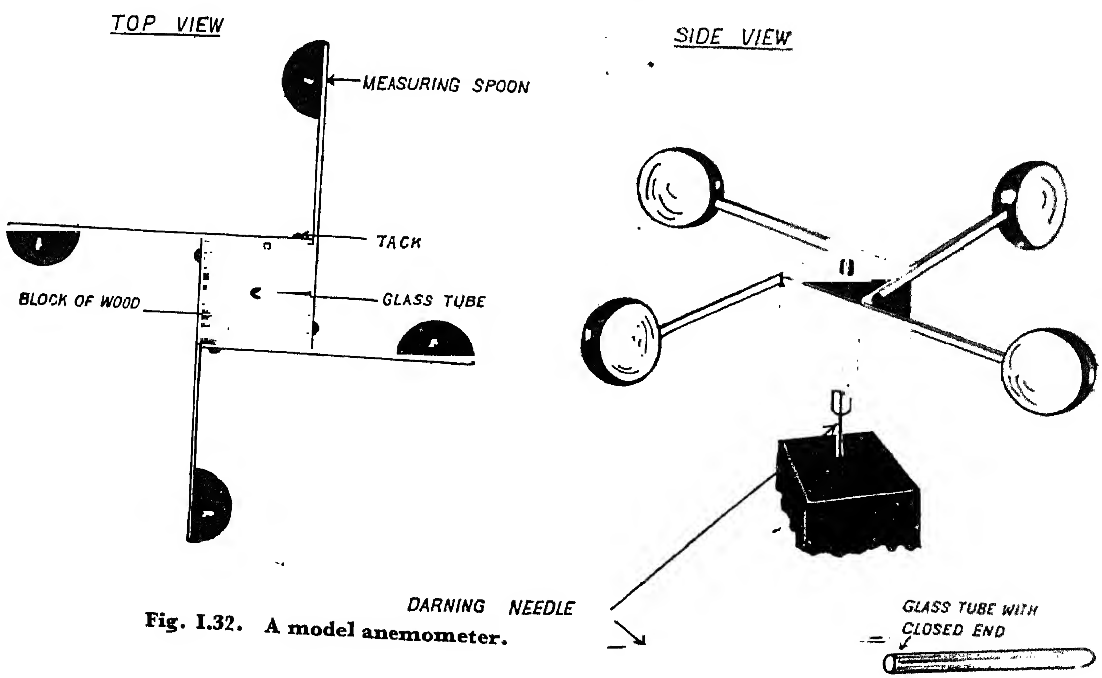


Fig. I.32. A model anemometer.

5. Get acquainted with the Beaufort scale and interpret your wind velocity this way also.

TABLE I-2 BEAUFORT SCALE OF WIND FORCE

Beaufort Number	Miles per hour	Description	Wind Effects on Land.
0	Less than 1	Light	Calm; smoke rises vertically
1	1-3	Light	Wind direction shown by smoke drift; but not by wind vanes.
2	4-7	Light	Wind felt on face; leaves rustle, ordinary vane moved by wind.
3	8-12	Gentle	Leaves and small twigs in constant motion; wind extends light flag.
4	13-18	Moderate	Raises dust, loose paper; small branches are moved.
5	19-24	Fresh	Small trees in leaf begin to sway.
6	25-31	Strong	Whistling in telegraph wires; umbrellas used with difficulty.
7	32-38	Strong	Whole trees in motion; inconvenience felt in walking against wind.
8	39-46	Gale	Breaks twigs off trees; generally impedes progress.
9	47-54	Srong gale	Slight structural damage occurs (chimney pots, slates removed).
10	55-63	Whole gale	Seldom experienced inland; trees uprootedted.
11	64-72	Storm	Very rarely experienced ; accompanied by widespread damage.
12 or more	73 or more	Hurricane	Countryside devastated.

6. Find out about the pressure plane type of barometer.

7. Water in the air is an essential ingredient of weather.

The rain gauge collects rainfall in such a way as to measure the accumulated depth in inches or fractions of an inch. Find out how the rain gauge at a weather station works.

To measure rainfall to the nearest tenths of an inch, get a tin or jar at least 6 inches high and 3 inches in diameter, preferably wider. Make or get a tin smith to make a funnel of the same diameter. Find a narrow flat-sided bottle such as a medicine bottle to use as the measuring jar. Glue a strip of paper down one side. Pour water into the tin to depth of one inch. Transfer this to the bottle. Mark the top of the water and divide this into tenths of inches. (See Fig. I-33)

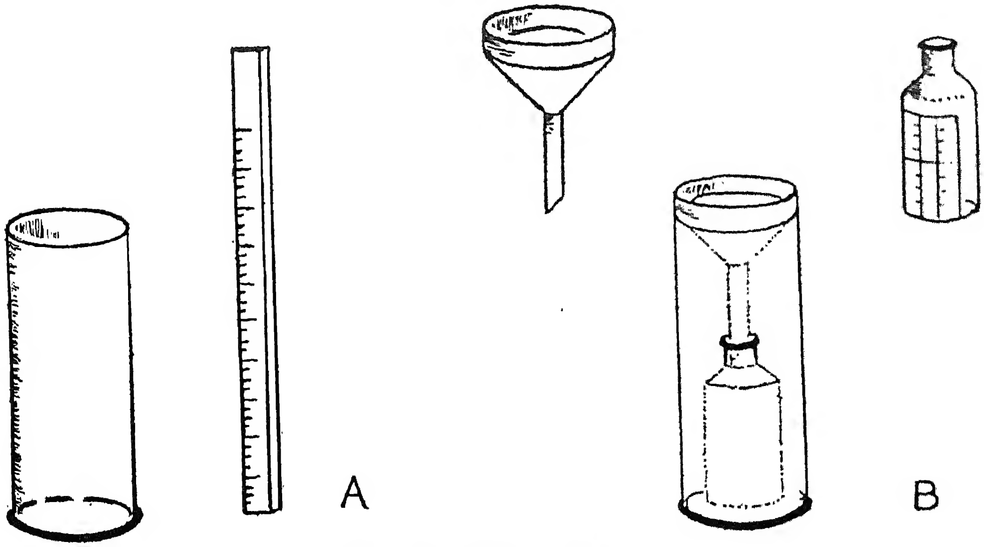


Fig. I.33. Rain gauge.

When the gauge is in use, it is best to keep the bottle inside the tin under the funnel. A rainfall of 1 inch or less can then be measured by direct reading from the scale and without pouring the water from the tin, thus avoiding the risk of loss of water. If more than 1 inch of rain falls during a 24-hour period, the bottle will be filled above the 1-inch mark and may overflow into the tin. To measure the rainfall, enough water must be poured out of the bottle into the tin to lower the level of water inside the bottle to the 1 inch mark. Then the bottle must be emptied, and the rest of the rain water measured by pouring it from the tin into the bottle (using the funnel to avoid loss). During very heavy rain, the fall may amount to several inches, i.e., you may have to fill the bottle to the mark several times; do this carefully and remember to count the number of inches you empty away.

NOTE: The straight-sided part of the bottle must hold the depth of one inch of water from the tin; for good results the tin (and funnel) must not be less than 3 inches across; nor must the height be less than 6 inches, otherwise splashing is likely to spoil the results. In other ways the sizes of tin and bottle do not matter.

Take a sheet of graph paper and show the amount of rainfall over the school year by colouring in a vertical column to the required height. Draw the horizontal lines at $\frac{1}{2}$ inch intervals.

8. A sunshine recorder or radiation gauge measures hours of direct sunshine in a day. The record is made with the help of a small black bulb.

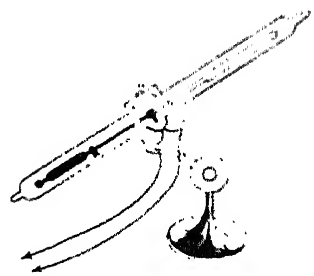


Fig. I.34. Sunshine recorder.

In order to understand how this works, try this :

Take two pieces of tin. Paint one with black dull enamel. Leave the other shiny. Mount these on a stand so that they may be placed either in the sun or have a light shine directly on them at the same angle. Secure with wax on the back of each board a match stick. Now place the black and shiny tins in the sun.

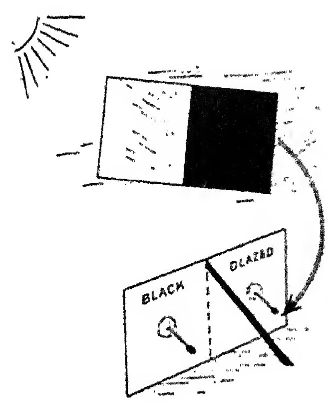


Fig. I.35. Which surface absorbs the sun's rays faster?

From which one will the match drop first ? Which tin absorbs the sun's rays faster ?

Now relate what you have learnt to the little black bulb on the sunshine recorder. Whenever the sunlight strikes the bulb, air inside warms up and expands. An electrical switch closes, causing a recording pen in the weather station to draw a line on a moving piece of paper. At the end of a day, a broken line shows when and for how long clouds blocked the sun's rays. What would an unbroken line show ?

Major Concept 2. Winds are caused by the difference of air pressure at different places.

Concept 2-a (p. 8) : The temperature of the air in the troposphere layer is the chief factor in determining the pressure of the air.

1. Does an equal volume of warm air weigh less than an equal volume of cold air ? Set up a demonstration like this. Procure two flasks of at least a litre capacity which you bring to a balance on your home- made balance. (Does your class-room have a metre stick balance ?) Heat one flask gently. Observe your balance as the flask, which you warmed, moves upward.

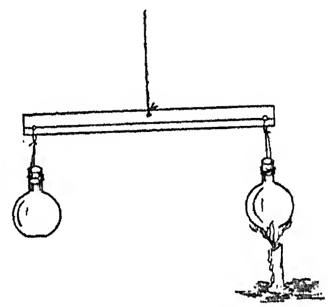


Fig. I.36. Which way will the balance move ?

Allow the flasks to cool to room temperature and then (like a good scientist), heat the other flask. Are the results alike ?

2. From what you know about the difference in weight and therefore, in pressure of warm and cold air, discuss the troposphere as the weather factory of the earth. You can understand that air expands when it is warmed, so that one part of warm air will occupy more space than one part of cold air. Warm air then is less dense than cold air; cold air is heavier, sinks down and so pushes the lighter, warmer air upward.

Concept 2-b, c (p. 9) : (b) Winds blow from centres of high pressure towards centres of low pressure.
(c) Winds are named after the direction from which they blow.

1. Mount the wind vane you have made and observe it. If one end is broad and the other end small as for instance in an arrow, the wind blowing will exert more force against the big surface and will swing the vane so that it points in the direction from which the wind is blowing. So if the wind vane points north, the wind is coming from the north. The same will be true for all other directions. Have you ever been to a weather station and watched the lights or a pointer on the instrument panel ? This pointer is connected by electricity to the wind vane mounted high on the roof of the station.

2. The other type of wind direction indicator is the wind sock which fills with air and flies with the wind.

Major Concept 3. Winds blow over the whole surface of the earth in a characteristic pattern.

Concept 3 a,b (p. 9): (a) Winds distribute the energy which falls from the sun unequally upon the earth warming the polar regions and cooling the equatorial regions.

(b) The winds of the earth blow in belts— belts determined by the unequal heating of the earth's surface and by the rotation of the earth.

1. Find out if the sun distributes energy unequally upon the earth. Is there a difference between the energy in the sun's rays as it comes straight down at noon on a hot summer day and when it shines at an angle in the afternoon of a winter day? Take two boxes of sand. Prop the boxes so that the sun shines directly on one and at an angle on the other. Insert thermometers in each box so that bulbs are at equal depths. Take the temperature every 15 minutes. Which box warms faster?

Demonstrate this by taking a globe and a torchlight. Flash the torchlight straight down near the equator. Mark the area of light. Now bring the torchlight in at an angle north of the equator. Mark this area. Do you see how concentrated is the first lighted area and how thin and spread out is the second? The original energy was the same, but in the second case a much larger area was covered less intensely.

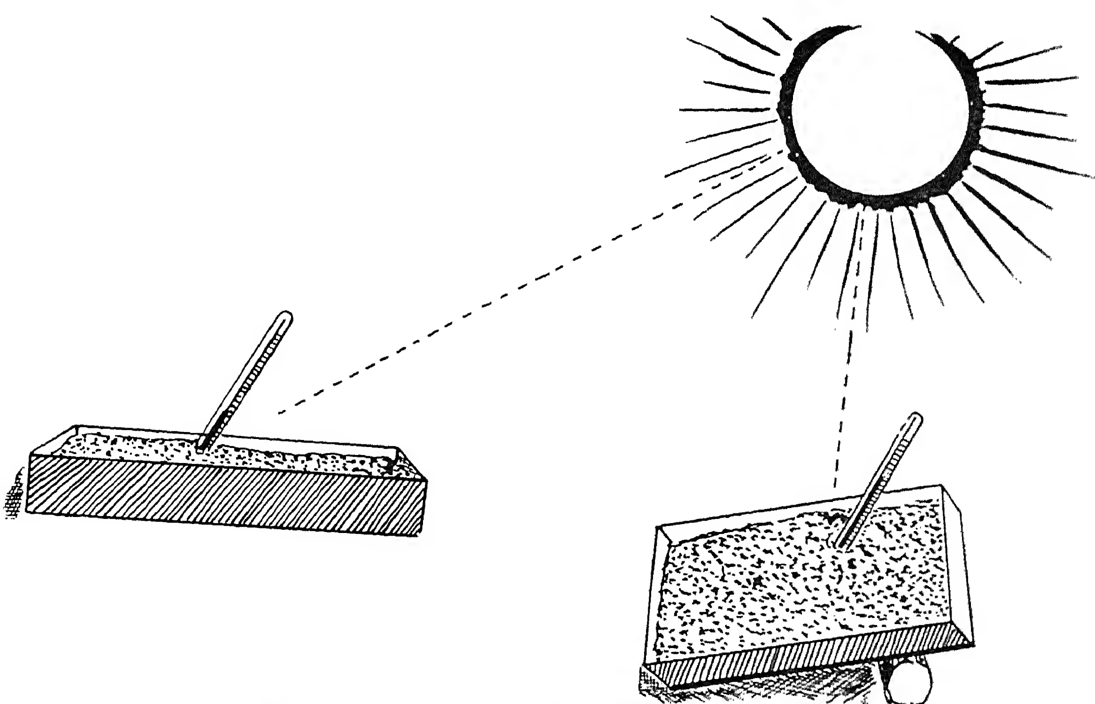


Fig. I.37. Is the sun's energy distributed equally?

If no globe is available, draw a diagram of the earth and simulate the sun's rays in the above locations. See the diagram. Large differences in temperature between the poles and lower latitudes arise from differences in the angle at which the sun's rays strike the earth.

2. Do all objects absorb the same amount of radiant energy from the sun? On a hot day why do you feel cool when you go swimming? To show the unequal heating of land and water, place some soil in one dish and fill a similar dish to the same level with water. Allow them to stay in a cool shady place until their temperatures are alike. Better still keep both in a refrigerator until you begin your experiment. Take the temperature of each. Set them in direct sunlight. Support a thermometer in each dish and take the reading every 15 minutes.

Relate what you found out to land and sea breezes. Do your results look like those in table I-3 ? Make a chart and graph of your results.

TABLE I-3

Minutes	Temperature of dish with water	Temperature of dish with soil
0	40	40
15	48	55
30	62	78
45	78	96
60	86	102
75	89	106
90	90	109

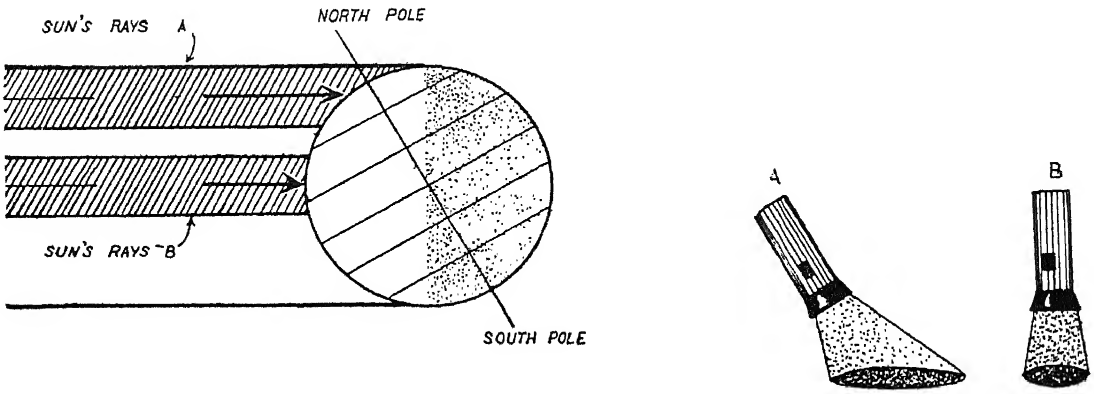


Fig. I.38. Unequal distribution of the sun's energy.

We have found in previous experiments (convection box) that unequal heating of air causes winds to blow. It is the winds that move over the surface of the earth distributing the sun's energy.

Build a three-chimney convection box. The candle provides heat at the centre of the box to make it correspond to the equator. The ends of the box correspond to the regions to the north and to the south of the equator. The bottom box will show winds moving along the surface of the earth; the upper box will show winds moving in the upper troposphere. The chimneys will show the movement above the equator and also above the polar regions.

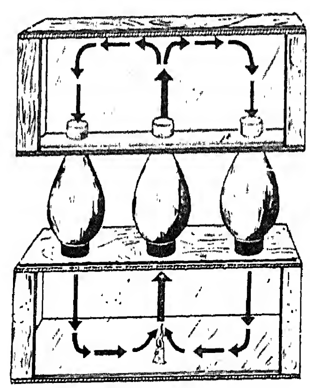


Fig. I.39. How temperature affects air movement at the surface of the earth.

Now, light the candle and follow the currents. See the current of air moving upwards, rising over the equator. See the currents of air moving downwards, descending at the poles. And along the surface of the earth, the winds are blowing towards the equator where they are heated and rise and

spread out away from the equator, blowing from the equator towards the poles, where they are cooled and descend.

The cold air descends at the poles, moves along the surface towards the equator, where it is warmed and rises. It then moves away from equator towards the poles, cools and descends again. This is a kind of cellular circulation that is set up in the troposphere.

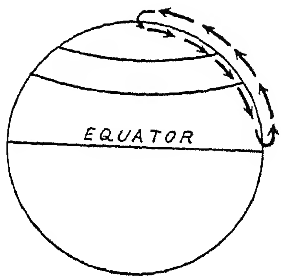


Fig. I.40. Earth's convection currents.

Most of the air that rises at the equator is sufficiently cool to settle down at the Horse Latitudes. It blows northward, cools and descends, and then spreads out to the south and to the north on the earth's surface.

Some of it returns along the surface of the earth to the equator as *trade winds*. The air in these winds goes round and round in a cell, as it did in the convection boxes.

Some of the air that descends at the Horse Latitudes, blows to the north in this belt. When this air comes in contact with the cold polar air coming southward, it moves up over the cold air, moves on to the poles in the upper winds, and settles down. Here is a second cell where the winds go round and round.

Some of the air that rises, when it meets the polar air coming southward, moves back toward the Horse Latitudes in the upper troposphere, there to settle down, and again blow to the north in the surface winds. So here again, the air in the troposphere moves in a cellular fashion. You may have observed this cellular circulation without realizing it. Have you felt the wind blowing from one direction, and then looked up in the sky and seen the clouds blowing in the opposite direction? Or perhaps in two different directions. Well if you have, you have observed cellular circulation.

But, so far, we have not considered the effe of the rotation of the earth on the direction of t winds. How does this rotation affect the directi the winds blow? Slip three cardboard rin over your globe, or large ball, one at the equa tor, one about at the Tropic of Cancer and th other at the Arctic Circle.

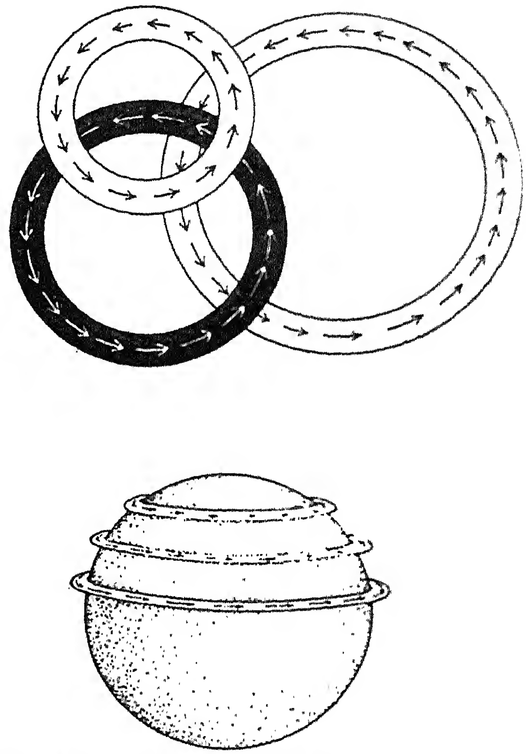


Fig. I.41. How does rotation influence the direction of winds?

Our atmosphere tends to rotate with the earth. The air above the equator tends to move eastward with the earth and so in a day will travel 25,000 miles. During this same time, air at the Horse Latitudes will move eastward only about 20,000 miles. At the sub-Arctic frontal zone it will move eastward none at all. Obviously the air over the equator is moving eastward faster than it does at the poles.

Since the air is moving eastward at different speeds due to the rotation of the earth, air which is moving northward in the cellular circulation tends to get ahead of the earth; and air which is moving southward tends to get behind the earth, because of its inertia. Air, like everything else,

tends to keep moving in a straight line at a constant speed, unless some force acts on it to change it.

Demonstrate that air tends to move in a straight line, and that due to the rotation of the earth, it follows a curved path.

Use a board to represent the earth's surface, and ping pong balls to represent the wind. Let one end of the board represent the equator. Let the top of the board, represent the Horse Latitudes. Let the wind blow without the earth moving. Note that it blows in a straight line, now. (Roll the ball.) Now move the board to the east—to your left—to represent the eastward movement of the earth's surface. Now watch what happens. Note that the ball appears to curve to the right.

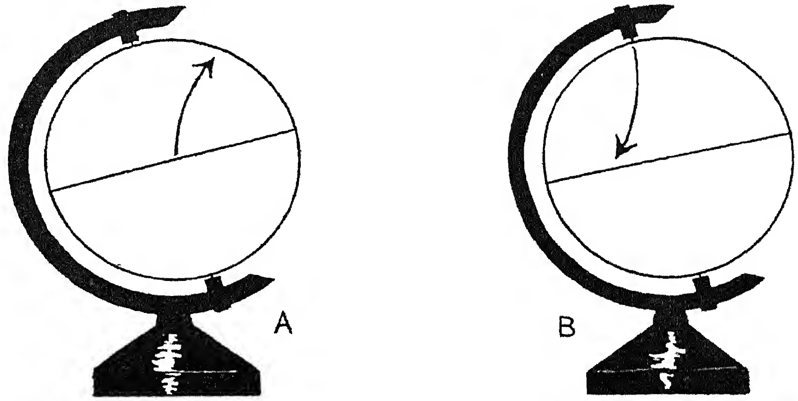
You will need a globe of the earth that is free to rotate. If the globe does not rotate on its axis, have it held and turned by hand. With a piece of soft chalk held near the position of the North Pole make a mark on the globe, moving your chalk straight south to the equator. If the globe is not rotating, your chalk mark will be a straight north-south line that follows the path of your piece of chalk. But, if the globe is spinning in an easterly direction as the earth actually does, the mark of your chalk will curve to the right to the west—although the path of the chalk was still straight from the North Pole to the equator.

Winds moving south are twisted to the right (to the west) owing to the rotation of the earth.

Now start at the equator of your rotating globe and mark a line straight north to the North Pole. Again, the path of your chalk will be on a straight south-north line. But, again the mark of your chalk will curve to the right (east) on the rotating globe.

Winds moving north are twisted to their right (to the east) owing to the rotation of the earth.

Fig. I.42. Why do north-south winds veer to the right?



Really the wind moves almost in a straight line, but follows a curved path over the surface of the earth, because as the wind is moving southward, the earth is moving eastward.

The direction of the wind must be changed too, by friction with the earth's surface, with trees, with hills, with mountains. If this is so, then we should be able to illustrate this effect by rolling balls over a rough surface.

You can make a rough board by glueing small pebbles on a board. Experiment by rolling your balls (the wind) over the rough surface.

The direction of winds then is modified by the rotation of the earth, and it is also modified by friction with the earth's surface. Actually in the northern hemisphere, any wind curves to the right due to the rotation of the earth. This phenomena happens both with surface winds and with winds aloft. And the cellular circulation is not strictly just a north-south circulation pattern, as it is also modified by the rotation of the earth.

By representing the surface winds on a chart, show the major wind belts in the northern hemisphere.

These surface winds, moving from the Horse Latitudes to the equator, are shown veering to the

right. These are called *trade winds*. They are also called *northeasterlies*, named from the direction from which they come.

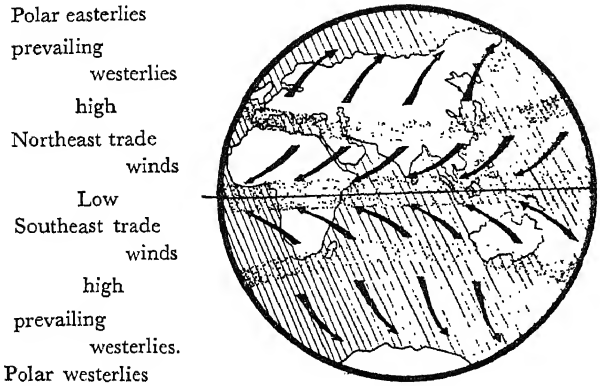


Fig. I.43. Wind belts.

These surface winds, moving northward from the *horse latitudes* veer to the right also, for they tend to get ahead of the earth as it spins beneath them. This belt of winds is called *prevailing westerlies*; more correctly, they may be called *southwesterlies*, since they are blowing from a southwesterly direction.

And the winds, where the polar air is moving southward, are called *polar easterlies*, more correctly they should be called *polar northeasterlies*, for they come from a northeasterly direction. These also veer to the right as they move from the pole towards the equator.

The *trade winds* are drying winds. They warm and pick up moisture as they move towards the equator. They are moderate in velocity and they blow steadily. In the days of sailing ships, these were the winds that could be depended upon to drive the ships of commerce. The *polar easterlies* are cold, high velocity winds that blow incessantly. The *prevailing westerlies* are variable winds; variable in speed and variable in direction. They usually blow from the southwest, however, and they are usually moderate in velocity.

Large masses of air having similar qualities are called *air masses*, and these masses are named according to their characteristics. *Air masses may be cold and dry; or cold and wet; or warm and dry; or warm and wet.*

Air which has been high in the troposphere will have lost much of its heat energy by radiation and so will be cold. *Thus descending air is cold air.* Also, it will have lost most of its moisture and so it will be dry. *Thus descending air is not only cold air, but it is also dry air.* So, it is cold and dry and exerts high pressure.

Air which has been moving along over the earth's surface, takes on the condition of the surface over which it has been moving. For example, air moving over ocean becomes wet; air moving over desert becomes dry; air moving over warm land or water becomes warm, and air moving over cold land or water becomes cold.

Study the facts about the circulation of winds at the surface of the earth. Consider what alters the direction of the winds. Realize there are also winds aloft. Construct in your mind a model to show cellular pattern of circulation, then draw it.

Major Concept 4. Energy absorbed when water evaporates is distributed by winds and released when water vapour condenses and precipitates.

1. Review several simple experiments on evaporation so that the factor of heat energy involved becomes apparent.

(a) Wet one hand with warm water. Wave both hands in the air. Which feels cooler?

(b) Set up an experiment to show that evaporation is speeded up by a rise in temperature, by moving air, and by larger exposed areas.

(c) Why do people feel cool on even a hot day after getting clothes wet in a rain storm?

Explain what is happening when you perspire and fan yourself. Why do you feel cool? What makes the moisture to evaporate? You say, heat energy. So if heat energy is used in evaporation, it must be stored and used in some other way. It is absorbed when water evaporates and is released when water vapour condenses and precipitation occurs. Can you relate this energy to storms?

2. Complete the water cycle of evaporation,

condensation, and precipitation. Heat some water in a beaker or dish. Place some ice water in a flask and lay the flask over the glass. Watch water droplets form on the outside of the cold flask (condense) and gradually drop (precipitate).

You may think of another way to show this.

Concept 4 a. (p 9) : Clouds are of different kinds.

1. Make a cloud and see for yourself the ingredients needed. Take a glass jug, wash it in order to be sure that moisture is present. You will need something on which to collect the moisture so 'seed' the air in the jug with smoke from a lit match. Now with the suspended smoke particles, the moisture and the air, what is necessary to make a cloud ? Blow hard into the jug; you compress the air molecules. And now for a way to cool that air. Recall how the air you let out of your bicycle or car tire felt? Quickly release the pressure, and the air in the jug cools and a cloud forms inside the jar. By holding it up against a dark background, this cloud is easily visible. Read about cloud seeding experiments, and report to your class.

2. Observe cloud forms and compare them with pictures. Draw the cloud forms you see with white chalk on blue paper- Describ the conditions out of doors when you see a certain cloud form. Learn the common forms of cumulus, cirrus, stratus, nimbus. (Fig. I.45)

Fig. I.44. Make a cloud in a bottle.

Fig. I.45. Cloud formations.

3. If someone in your class has a camera, a collection of photographs of cloud forms can be obtained and matched with daily observations of the clouds. Do clouds change in a definite way before a change in weather? Describe a thunder cloud and the conditions you observe at the time.

Concept 4-b, c (p.9): (b) Storms are of different kinds.
(c) The violence of certain storms indicates the vast amount of energy released. It is the latent energy of the water vapour that is released in storms.

What do we mean by storms? Perhaps you live in an area where the weather does not change noticeably from day to day. This is not so in many parts of the world, especially in the temperate zones. There masses of cold and warm air move across land and water, taking on characteristics of the area they move over. These air masses differ in temperature and hence in the pressure and the speed with which they move. When they meet a boundary or front is formed.

Possibly the following demonstration will clarify the meaning of 'fronts'. Half fill a flat bottle with water and fill the remainder with heavy motor oil.

(a) Cork the bottle and tip it to one side. (see figure).

What do you think happens when a cold front meets a warm? (The cold air is heavier and slides under the warm.) What happens if a warm air mass meets a cold? (The lighter air will slide over the cold and will cool as it rises probably producing clouds and rain.) Thunderstorms are common as a cold air mass advances under a warm air mass. Keep track of thunderstorms in your area. See if you can predict their occurrence. If the cold heavier air keeps forcing the warm air up rapidly, say several miles, the moisture in the warm air may freeze and we get cirrus clouds, warning us of an approaching storm.

Tornadoes and hurricanes are violent storms created by the interaction of air masses greatly differing in temperature and pressure. Get more information on these storms, their causes, and the destruction they cause. Find out how science is helping man to anticipate storms.

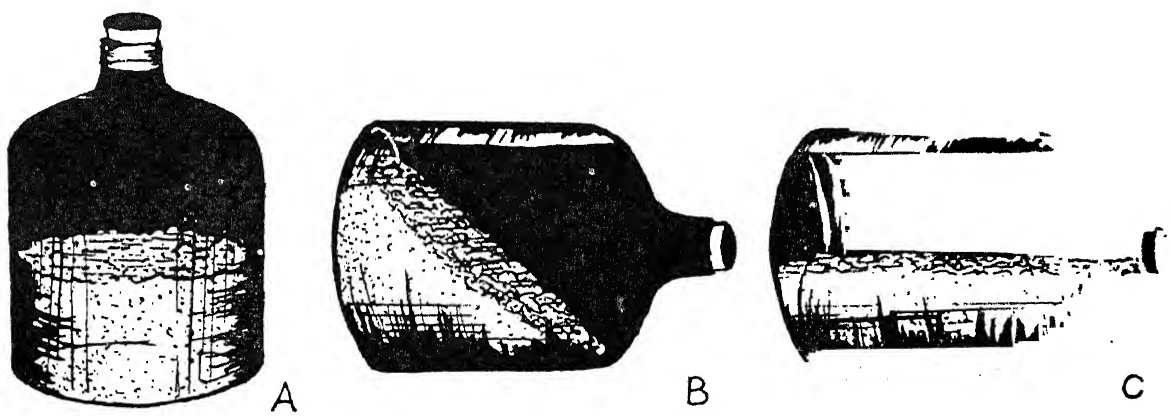


Fig. I.45. Fronts.

(b) The boundary between the two liquids is a 'front'. The water represents a cold air mass and the less dense oil represents a warm air mass. Try to show how the water moves under the oil and how the oil slides over the water. Note the turbulence that occurs along the front in steps B and C where the two different liquids are in contact.

In trying to understand violent storms, recall that the cooling effect of evaporation was due to heat energy removed, but also that heat energy was absorbed in the water vapour and later released during violent storms.

Draw a series of sketches showing the cycle of a summer rainstorm. The first sketch might show the formation of a layer of moist warm air near the earth under a layer of cooler drier air. The stage might show the warm air being pushed up through the cooler air. The third would be the formation of cumulus clouds as the warm air rises rapidly. Following this usually precipitation occurs, caused by rapid expansion and cooling of warm moist air. Lightning, thunder, high winds, rain or hail may result.

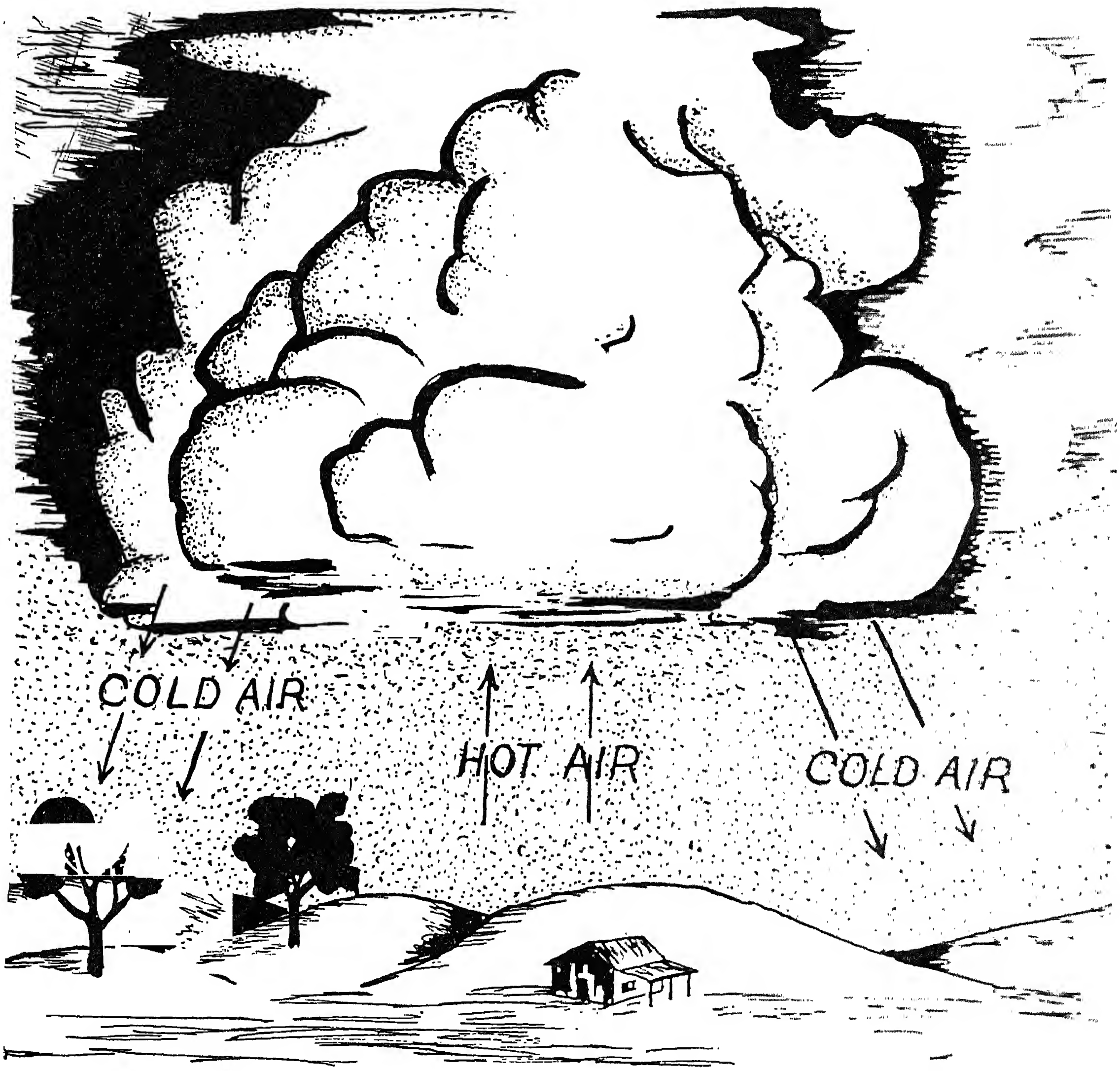


Fig. I.47. Thunderstorm.

Concept 4-d (p.9): Lightning conductors are used to protect buildings from lightning.

Lightning is the discharge of static electric charges. Read the historical account of Benjamin Franklin's scientific explanation of lightning, how he captured lightning in order to understand it. In this way he devised a conductor for electricity, or an easier path from sky to ground, so

that buildings could be safe in electrical storms. He called his conductor a lightning rod. Many people ridiculed him. Do yon think it a good idea? Why did he have the rod go into the ground deep enough to touch wet earth?

Major Concept 5. Data obtained regarding the temperature of air, its pressure and its humidity can be used for forecasting weather.

Concept 5 (p.9): (a) High temperature forecasts the formation of low pressure.
(b) Low pressure forecasts strong winds or storms.
(c) High pressure forecasts fine weather.
(d) Greater humidity forecasts low pressure.

1. Locate a weather map. Find the spots marked Highs and Lows. Highs generally bring fair weather; lows poor weather. High temperatures mean warm air masses with low pressure (recall the characteristics of warm air). Since winds move from high pressure to places of low pressure where would you expect greater humidity, where the air is warm or cold? Does this help you to see that since warm air holds more moisture than cold air, you may say that greater humidity forecasts low pressure?

2. Set up your weather instruments so that you can observe and try predicting the weather. Check your observation with a weather bureau or daily weather maps in the newspapers.

3. Find out about and report on the cyclonic storms that form in the Bay of Bengal, the *northwesterlies* of Bengal, the dust storms of Northwest India, the southwest monsoons. Describe weather-wise the conditions at the time of these storms.

4. Find out about the use of radiosondes to obtain readings of temperatures, pressure and humidity of the upper air, providing data for weather forecasting.

5. Compare data you find on calendars and in almanacs on weather predictions. How accurate are they?

6. Have a field trip to a local Weather Bureau, if at all possible. Perhaps your local air-port has one.

7. Follow your parallel of latitude around the world. Compare climate at various places around the world. Account for differences.

UNIT II Rocks, Soils and Minerals

CLASS VI

Major Concept 1. Different types of rocks are found under different conditions.

Concept 1-a **(p. 10)****:** The sedimentary rocks have been formed at the surface of the earth either by the accumulation and cementation of fragments of rocks, minerals, and organisms, or as precipitates from sea water.

If you are interested in finding out about rocks and minerals, explore places like gravel pits, stone quarries, stream beds, river and ocean shores, fresh road-cuts, and mountainous regions.

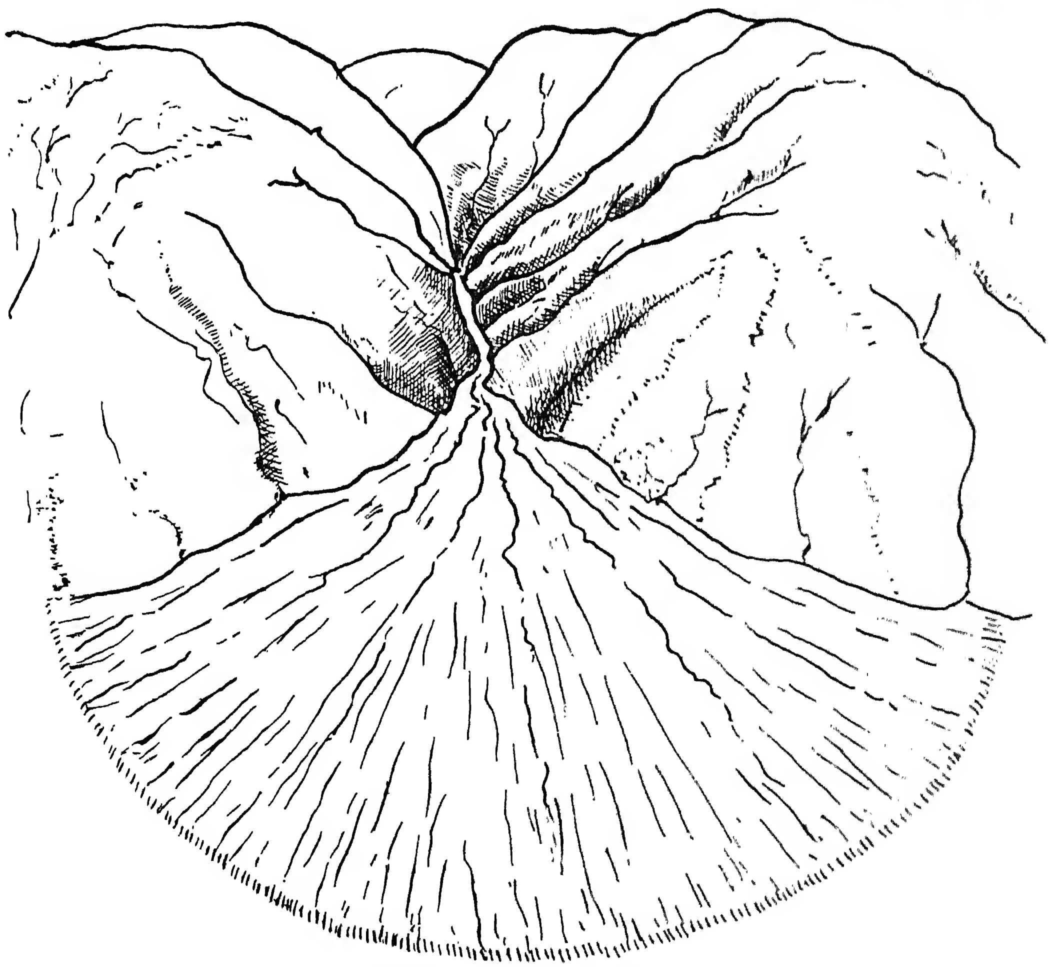


Fig. II. 1. An alluvial fan.

1. How are rocks moved from one place to another ? The carrying capacity of water varies approximately as the fifth power of the velocity. Thus if water doubles its velocity, it will carry about 32 times as much sediment in suspension. $(2.2.2.2.2=2^5 = 32)$. Thus if you wished to locate freshly deposited sediments, sediments dropped by running water, where would you look? You would look at the foot of a gulley, at the bed of a hill, or at the base of a pile of loose earth or of limestone or other rock material. You would expect to find at the base of each small gulley, a fan-shaped, relatively flat deposit of fine material.

2. Or, you would look where a stream flows into a lake or a sluggish large stream. There would probably be a deposit known as a sand bar or a delta where the water is shallow. If a field trip to a stream is not possible, use a sand box in the classroom to demonstrate the effect of a stream of water on it. The result of changing stream velocicity on quantity of load rate, the size of particles carried and the way they move can be shown.

This sand is deposited in a wide flat river-bed with the main channel shifting from time to time. See the sand bar on the inside of the curve in the river. During the dry season, farmers grow watermelons on these sand bars. About four-fifths of the surface of the earth are covered with layers of rock that were laid down in water. These rocks are called *sedimentary* (from sediments laid down) rocks.

4. Visit a place where you can be sure how the sand was laid down as sediments. Collect samples of the sediments and bring them back to school to examine closely. Then with a hand lens look carefully at the grains of sand. These grains are probably mostly quartz grains, for quartz is hard and so pulverizes slowly. Are the grains nearly all about the same size? (They will be in a single sample, but if you collect some samples where the water moves fast and others where it moves slowly, the size of the particles in the two samples will differ.)

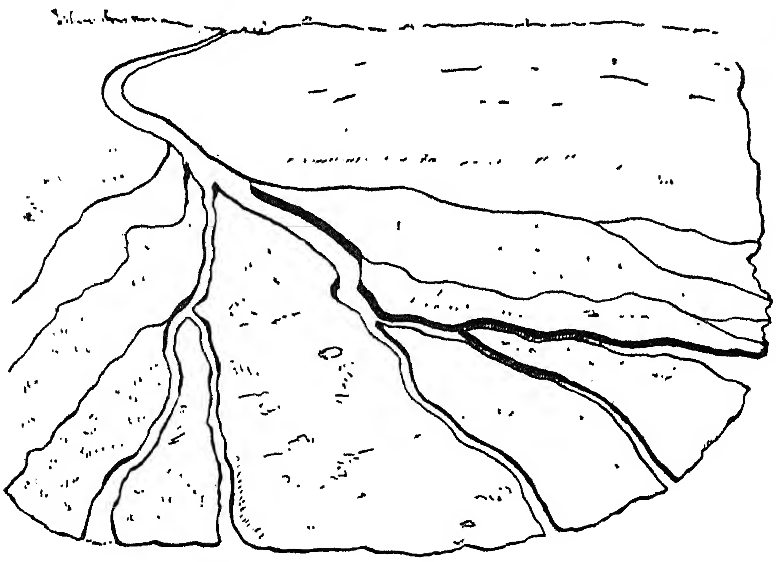


Fig. II.2. A river-formed delta.

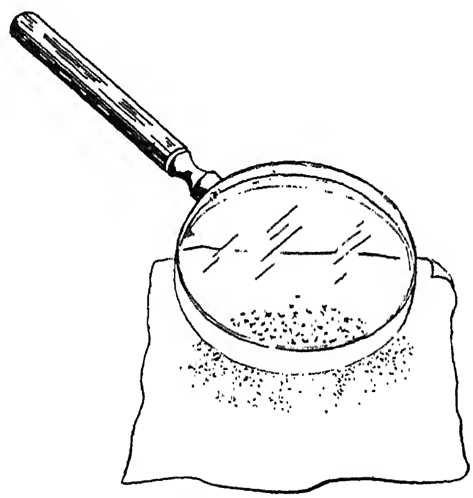


Fig. II.3. Sand seen through a hand lene.

3. Still a third place to find a deposit is on the inside of a bend in a river or stream—the water flows faster on the outside of the bend and so deposition occurs on the inside of the curve. Many streams flow rapidly during the monsoon period, bringing sand down from the mountains.

Are the grains alike in shape or do they resemble small fragments that have had the edges and corners rubbed off ? Are there any sharp edges on the grains ?

To show that coarse sediments settle out first and fine sediments only after the water slows down, put a cupful of sand and a cupful of clay in a round glass jar of about 4-litre capacity, nearly fill

the jar with water, and then swirl the water rapidly by moving the jar in a circular fashion. Stop swirling the jar and allow the sand and clay to settle. Do they settle all at once, or does the sand settle first, and then the clay, in another layer on top of the sand? You may wish to test other materials. You can try some small pebbles and some powdered chalk along with your sand and clay. Shake them vigorously in a jar and allow them to stand until the water is clean. How does it look?

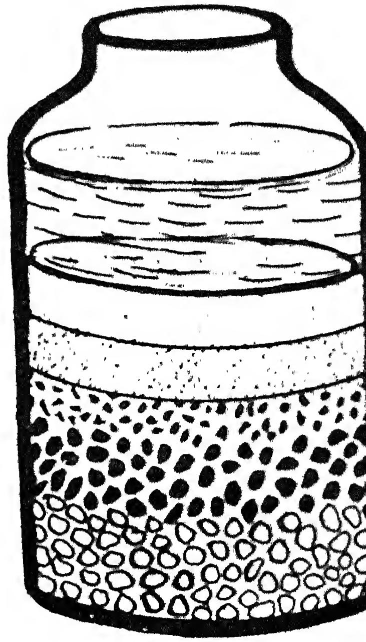


Fig. II.4. Materials in water settle in layers.

To show how precipitates might settle out of sea water, dissolve as much salt as you can in boiling water, then pour the solution into a shallow dish and let the water evaporate. There should be a deposit of salt along the bottom and the edges of the dish.

Concept 1-b (p. 10): Formation of sedimentary rocks is a very slow process.

To gain an idea that the formation of sediments is a slow process, recall that the level of the sediments in a stream bed, does not change enough during the years for you to notice the building up process. Also notice the very thin layer of fine sediment that forms a crust over the bottom of a mud hole each time when the mud hole is filled with muddy water and then evaporates. Observe this on a playground after a rain storm. By discussion arrive at the conclusion that sediments build up slowly. Certain estimates have been made that on the average it takes about a thousand years for a foot of sediment to accumulate.

Concept 1-c. (p. 10): Igneous rocks have formed from liquid lava that solidified on cooling.

The melting temperatures of rocks are so high that you cannot melt rocks in your home, laboratory or school. However, you may have seen small pieces of glass that have been melted or partially melted in a very hot furnace or fire. How, then, are we so sure that igneous rocks have formed from molten rock that solidified on cooling? One way we know is that in some places man has seen rivers of molten rock flowing from a volcano, and later has seen these cool and solidify into rocks. When such rocks are quenched in water they freeze quickly and resemble glass. They are called *volcanic glass* or *obsidian*. Perhaps you have seen arrow heads made of obsidian. When the molten lava is bubbling with gas, it becomes frothy and forms a rock full of holes known as pumice *basalt*.

When the lava cools in air it forms a fine-grained crystalline *basalt*. When a large mass of hot solid rock cools, it contracts, and as it contracts it splits in slivers at right angles to the cooling surface.

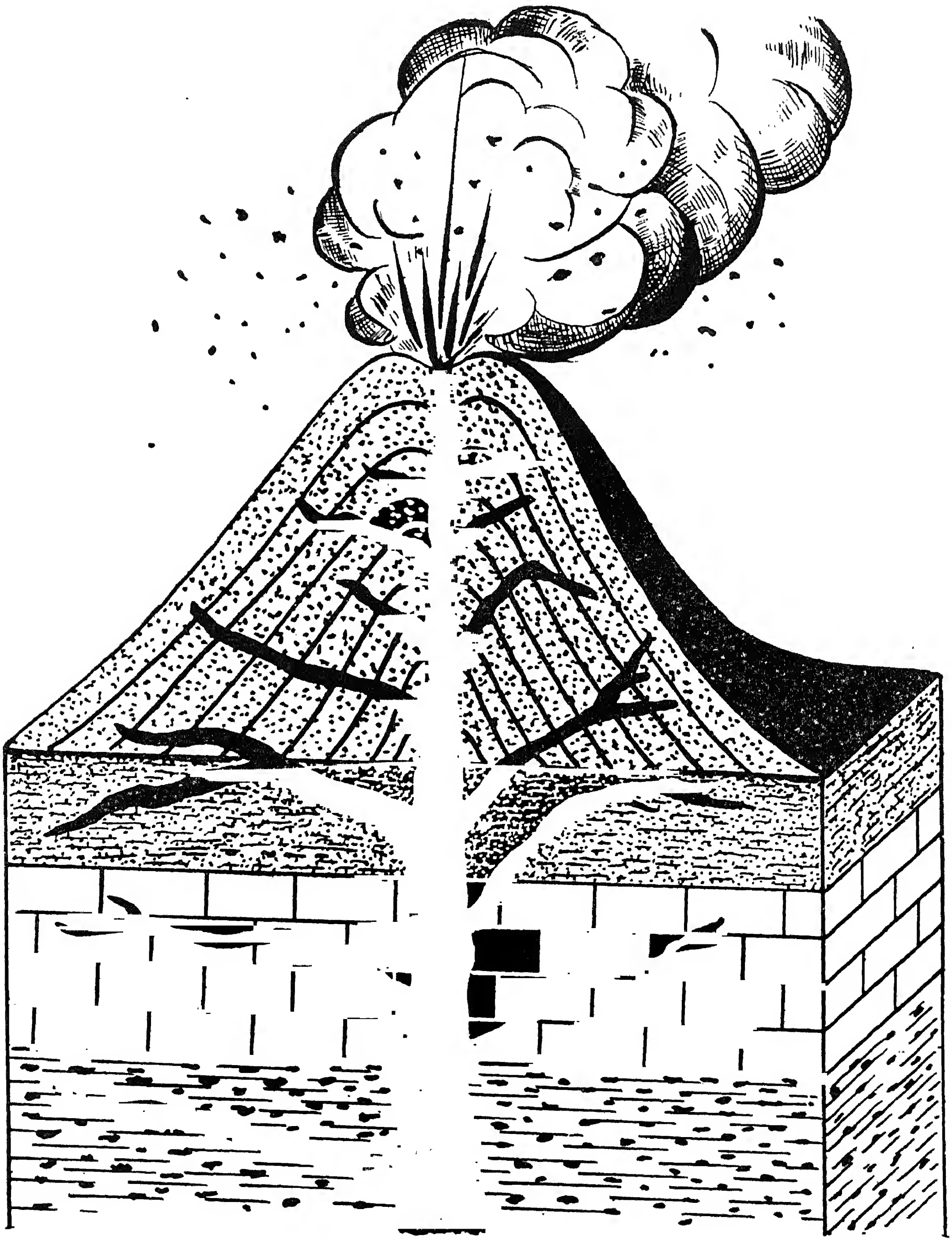


Fig. II.5. Structure of a volcano.

You may wish to make a volcano in your classroom. A safe volcano can be made by inserting a funnel in a *papier mache* volcano, attaching a bicycle pump and blowing very tiny bits of paper (confetti) or small pieces of saw dust through it.

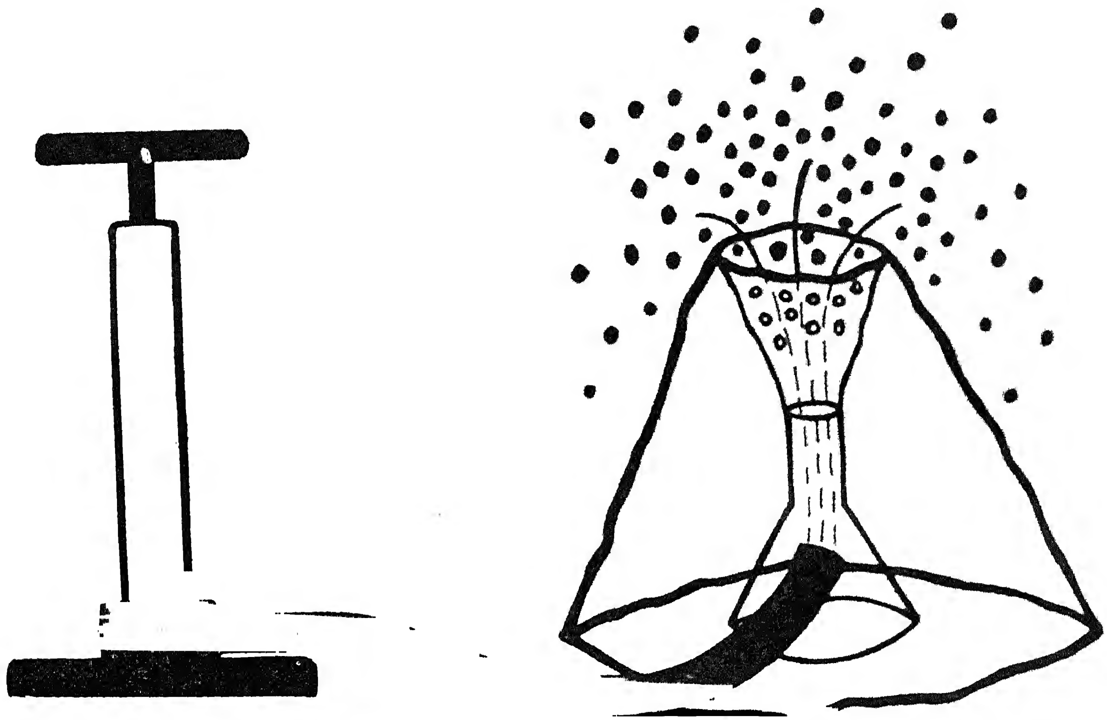


Fig II. 6. A model volcano.

A more ambitious type of volcano can be made by using either steam or chemicals. These should be used only under supervision. Collect and examine specimens of igneous rocks. You will find granite in many places. Note the way in which they break when you hit them with a hammer they are crystalline or glassy, they are not an [illegible] of cemented sediments so they break with sharp edges. Igneous rocks are usually massive in structure and occur in large blocks. They are frequently columnar with the columns formed by vertical cracks as the lava cooled. They may be dark-coloured or light-coloured like the granite and pegmatite.

Concept 1-d (p. 12): Igneous rocks have formed both on the surface and below the surface of the earth.

---

1. When lava moves in between layers of solid rock, it cools slowly and the crystals of which it is composed grow large. You may get an idea of how lava moves in and out between layers by taking a partly used tube of tooth paste and squeezing it from one end to the other. Roll the tube up tightly and puncture it near the top with a pin. The effect of eruption can be simulated. Thus coarse-grained igneous rocks are made up of interlocking crystals of minerals that can be easily seen. Examine specimens of granite and of pegmatite with the naked eye and also with a hand lens. In these specimens you will find three minerals, namely, quartz, feldspar and mica. The quartz is glassy in appearance it fractures like glass. The feldspar cleaves along definite planes leaving flat surfaces on the top, bottom and side of each crystal. The shiny mica forms hexagonal-

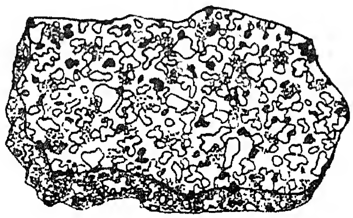


Fig. II. 7. Granite.

shaped crystals that cleave into their elastic layers across the top of the hexagon. With a knife and a piece of glass try scratching the three minerals and see how the mica, feldspar and quartz compare in hardness. Compare your findings with the scale of hardness.

Hardness tested by simple tools shown in Fig. II. 8, is used as a method of identifying minerals. There are more precise ways of measuring hardness such as the Mohs' Hardness Scale. This scale begins with talc as number 1 and ends with diamond as number 10. Rock specimens are graded in a comparison of which a sample can scratch other rocks or be scratched by them.

When on a field trip you may use these items for a quick check. Do not, however, test hardness on the face of a valuable crystal.

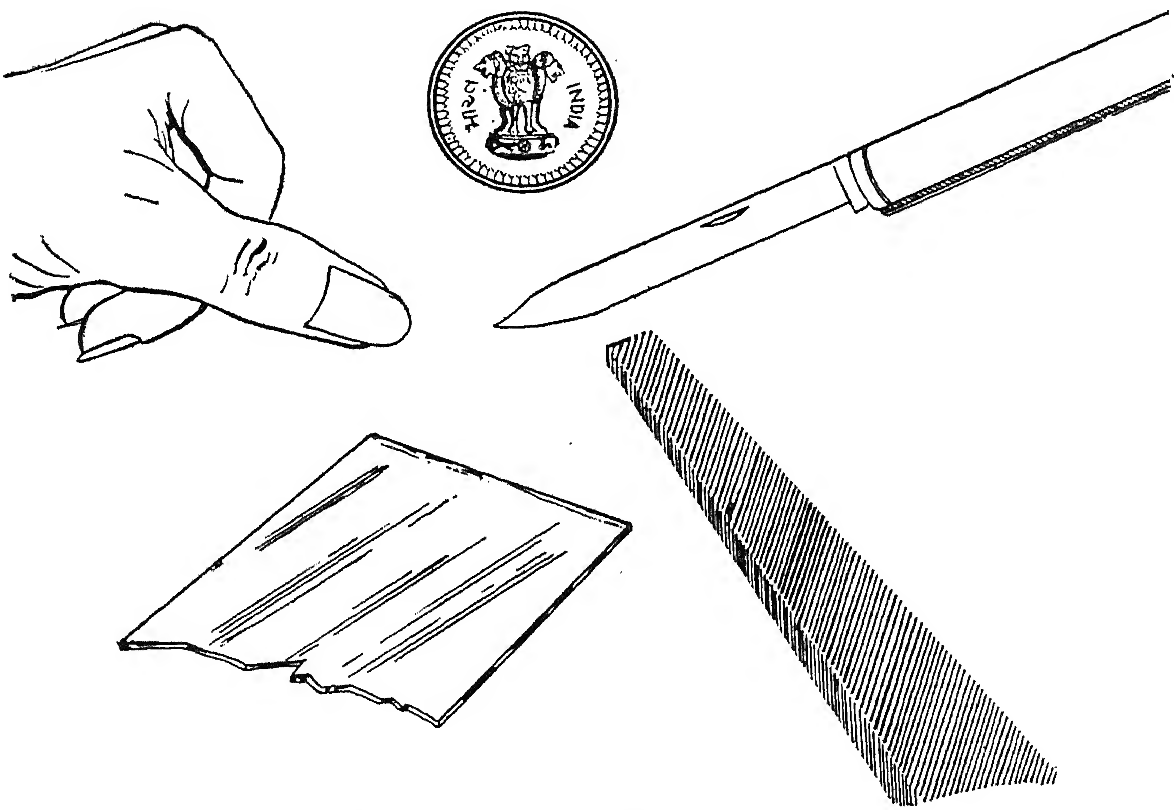


Fig. II. 8. Testing hardness of minerals.

MOHS' SCALE

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Feldspar
7. Quartz
8. Topaz
9. Corundum
10. Diamond.

Concept 1-e (p. 12): Metamorphic rocks have been formed out of pre-existing rocks [illegible] earth's surface under great changes due to heat, pressure and [illegible] changes.

Did you ever use a slate for writing? You then know a common metamorphic rock. Metamorphic means changed. These rocks have been changed by heat, pressure and chemical action deep in the earth and are quite different from the sedimentary or igneous rocks from which they came. Common metamorphic rocks are slate, mica schist, gneiss, quartzite and marble. All metamorphic rocks are crystalline, and the crystals are frequently oriented in a single direction, giving a foliose or leaf-like structure, as in the case of slate and mica [illegible] structure as in the case of [illegible] split easily along the [illegible] mica crystals.

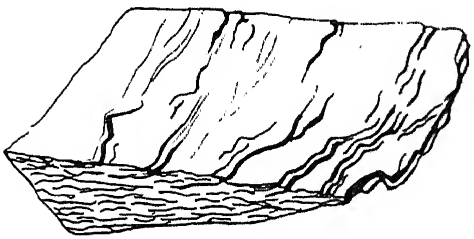


Fig. II.9. Slate.

Fig. II.10. Banded gneiss.

A quartzite rock consists of quartz [illegible] cemented together by crystals of quartz. It is a hard rock. When you hit it with a hammer, it will break right through the quartz grains and crystals, leaving sharp edges like broken glass.

Many of you have seen [illegible] Marble is a metamorphic [illegible] changed limestone. The calcium carbonate deposited as shells of which the limestone is [illegible] has formed interlocking crystals of calcite giving a massive structure.

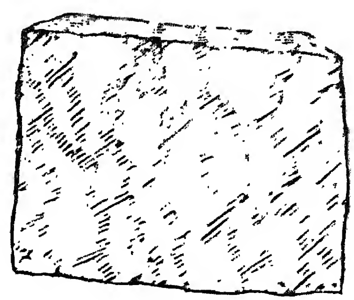


Fig. II.11. Marble.

Find and identify specimens of metamorphic rock by the characteristics given in the table below. If specimens are not available, try to locate someone who collects rocks and minerals to give a demonstration.

TABLE II-1. METAMORPHIC ROCKS AND THEIR CHARACTERISTICS

Metamorphic Rocks		
Texture	*Physical Features*	*Name of Rock*
FOLIOSE		
Coarse-grained-banded	Bands of different minerals; contains abundant feld spar.	Gneiss
Leaf-like structure	Flaky layers not distinct from each other; feldspar absent; mica, chlorite, and garnet schists typical.	Schist
Fine-grained	Slaty cleavage	Slate
No grain	Coal with high luster	Anthracite
NON-FOLIATED		
Very coarse-grained	Has the texture of conglomerate but the rock breaks across the grains as easily as it does around them. Pebbles commonly consist of chert, quartz, or jasper.	Conglomerate
Coarse-grained	Chiefly calcium carbonate (Ca CO_3); effervesces freely with dilute hydrochloric acid; colour variable.	Marble
Fine-grained	Dense (very heavy); dark-coloured	Hornfels

Major Concept 2. Changes in the form and location of rock materials are brought about by processes of weathering, erosion and deposition.

Concept 2-a (i) (p-12): Weathering is the crumbling of rock material without it being moved.

(i) Rocks weather chemically. The chief chemical agents are oxygen, water, carbon dioxide and acids from plants.

To see that weathering is the crumbling of rock material, take a piece of dull weathered igenous rock and break it. Note the difference in appearance of the freshly broken surface, and of the outside which has been acted upon chemically by agents in the atmosphere. The reddish outside appearance is probably due to the oxidation of iron crystals in the rock to haematite—a common rusting process. If the outside is yellowish, the iron of the rock has probably combined with both oxygen and water forming the mineral limonite. As certain minerals combine with the oxygen or

water in the air, then these minerals swell up forcing other crystals apart. Have you noticed how a rusting bolt increases in size as it rusts? You can no longer turn the nut easily.

To show the effect of acids on limestone or marble, place a small chunk of freshly broken limestone in an acid. After several days see if the sharp edges have been dissolved away. You may use a concentrated amount of vinegar, lemon juice or (under supervision) hydrochloric acid.

Still another way to show this effect is to blow your breath through lime water. At first the lime water will turn milky as the carbonic acid from your breath combines with the calcium hydroxide of the lime water. This milky precipitate is calcium carbonate, the chemical of which limestone is chiefly composed. Now if you keep on bubbling your breath through the lime water it should become clear again. The carbon dioxide of your breath forms a weak acid which dissolves the limestone particles. This is like what takes place in limestone rocks in the formation of caves.

Concept 2-a (ii) (**p.12**): Rocks weather mechanically. The chief mechanical agents are quick changes in temperature, freezing, and the growth of plant roots.

To show the effect of changes in temperature heat a small piece of crystalline rock about the size of a walnut in a flame until it is very hot. Hold it in the flame with tongs. Then quickly quench it in cold water. A piece of the rock should break off.

Try the same experiment using a small piece of a glass or a small glass bottle. The sudden change of temperature should shatter the glass, for with a change in temperature the volume changes, and if one side is hot and the other is cold, or if it is hot in the middle and cold on the sides, the sudden change in temperature causes stress and fractures the glass. Note the difference between shattering of glass and the breaking of the rock.

To simulate the effect of the freezing of water in crevices in a rock, fill a bottle completely with cold water, seal it tightly and then freeze the water to ice in the freeze compartment of a refrigerator. The expansion of the water on freezing should break the bottle. Try this experiment with a freezing mixture of ice and salt in a bucket, if a refrigerator is not available.

Concept 2-b (**p. 12**): Erosion is a grinding or gnawing process. Rock material always moves. When erosion takes place, deposition also takes place somewhere else. The chief agents of erosion are:

(i) Running water
(ii) Wind
(iii) Moving ice (glacier)
(iv) Gravity (rock-falls from a cliff).

1. To show that when rock materials are rubbed against each other, these materials become pulverized, rub different rocks together and see if you can pulverize some of the rocks by this process. Try rubbing a piece of quartzite, against a piece of slate, or a piece of basalt or granite against a piece of slate or limestone.

Record your results. The softer rock should be scratched by the harder rock, and get somewhat pulverized.

2. Discuss the various ways in which rock materials are moved. Compare the size of the pebbles or sand found in a fast mountain stream and in a sluggish stream; on a protected sea beach, and on a rocky promontory where the waves are bigger and the water moves faster.

3. Collect pictures of glaciers (moving masses of ice) and landslides showing the effects of erosion. If a film is available, use this.

Concept 2-c (p. 13): The nature of deposited materials depends upon the erosive agents.

(i) Running water deposits large rocks when flowing very swiftly, pebbles when moving swiftly, sand when moving slowly, and fine clay particles, when nearly still.

(ii) Wind carries fine particles only; fine sand and silt.

(iii) Ice carries fine silt, sand, rocks. Deposits are a conglomerate.

(iv) Gravity-Deposits at the foot of a cliff include rock material of all sizes.

Plan a field trip to study some effects of erosion. Identify situations in which you are quite sure how the sediments were deposited and the agent that caused erosion, and the rapidity of movement of the agent. Then study the deposits to see if they are uniform in size or variable in size, whether the sediments are fine or coarse, and what are the shapes of the individual grains or pebbles. Try to account for what you observe. If unable to observe in the field, get a geologist to come to your class. Possibly he may have coloured slides of his field trips to show you.

Major Concept 3. Mineral constituents of a rock may be igneous at one time, sedimentary at another, and metamorphic at another time.

Concept 3-a, b (p. 13, 14): (a) As a rock, for example granite, is eroded, the hard minerals (quartz) pulverize the softer minerals, (feldspar and mica). The hard minerals also erode the other hard particles. The result is that the minerals are sorted according to size of particles, because of differing hardness.

(i) Quartz is deposited as sand.

(ii) Mica and feldspar are deposited as clay.

(iti) The sand sediments later become cemented together to form sandstone (sedimentary rock). The clay sediments become cemented together to form shale (sedimentary rock).

(iv) Under conditions of heat and pressure, the sand may be cemented together with quartz to form quartzite (metamorphic rock); the shale may be changed to form slate or mica schist (metamorphic rocks).

(v) Under conditions of heat and pressure, alternate layers of sandstone and shale may be changed to form gneiss (metemorpic rock).

(b) Limestone, a sedimentary rock composed largely of the mineral calcite, may be changed by heat and pressure to form marble (metamorphic rock). Either limestone or marble could be dissolved in lava to become a part of igneous rock.

1. Study Table II-2 to see how the same materials may at one time be considered igneous, at another sedimentary and at still another time, metamorphic. Make a large

poster for your school museum like this diagram with mounted specimens of rock materials showing the various stages that might occur. The following Table shows how the minerals of granite, quartz, feldspar and mica may be changed to other kinds of rock by weather and erosion. It also shows how the mineral in calcite may be changed to limestone.

2. Try the following experiment:

Dissolve a half teaspoonful of sulphur in five tablespoons of carbon disulphide. Pour on a glass plate and allow the mixture to evaporate. Small crystals will form. The crystals that form in this way are similar to the crystals that separate from water and form sedimentary rock.

Put sulphur one inch high in a test tube and heat very gently over a low flame, so that the sulphur melts. (Note: Be sure that in heating, the sulphur always remains a straw-coloured liquid). Pour into a cone made of filter paper and let it cool. A hard crystalline lump of sulphur will form. This is similar to igneous rock.

Take the sulphur remaining from the two experiments above and place in another test tube and heat vigorously until the sulphur turns red. Pour into a container of water. Feel the sulphur after it is cooled. Note that it differs greatly from the sulphur in the two preceding experiments. This is illustrative of the change in characteristics of metamorphic rocks.

TABLE II–2. ROCK MATERIALS MAY CHANGE IN FORM OVER A LONG PERIOD OF TIME

Igneous rocks	Sedimentary rocks		Metamorphic rocks	
Minerals in granite				
quartz →	sand →	sandstone →	quartzite	
			→ gneiss	
feldspar mica →	clay →	Slate →	slate —	mica schist.
Mineral in calcite →	limestone →		marble	

Major Concept 4. Rocks show the characteristics of the minerals of which they are chiefly composed.

Concept 4-a (p. 14): Limestone and marble are relatively soft rocks and may be easily cut. Calcite, the mineral of which limestone and marble is chiefly composed, is relatively soft.

1. Procure a small piece of marble and try carving some form in the marble with a steel chisel and a hammer. Note that it is cut rather easily—that it is much softer than the steel chisel.

2. Examine the school and other public buildings to see the type of natural rock used in construction. Locate places in your community where marble, granite, slate, sandstone, and limestone have been used.

Concept 4-b (p. 14): Limestone and marble rocks are easily dissolved in weak carbonic acid from decaying organic wastes. This is a characteristic of the mineral calcite of which it is chiefly composed.

To see if carbonic acid really does dissolve limestone, place some limestone or marble chips in a glass of water and bubble carbon dioxide from your breath through the water. The carbon dioxide from your breath forms carbonic acid in the water. After blowing for about 15 minutes, remove the marble chips and ev porate the water. Compare the deposit left in this glass with that from an equal amount of water in another glass to which no limestone was added.

Concept 4-c (p. 14): Shale, slate and mica schist rocks are softer than sandstone, for the minerals of which they are composed are softer.

Do slate and mica schist rocks contain a good bit of mica ? Try scratching a piece of mica mineral and then scratching each of these specimens. Do they all scratch readily ? Could they be said to be roughly similar in hardness ?

Now try scratching a piece of sandstone and a piece of quartz. Can you scratch either one ? Are they similar in hardness ? Do these rocks have about the same hardness as the minerals of which they are chiefly composed ?

Concept 4-d (p. 14): Slate and mica schist tend to split in thin layers as does the mica mineral of which these rocks are largely composed.

To show that the tendency of slate and of mica schist to split into their layers is due to the mineral mica of which they are chiefly composed, try splitting specimens of each and of mica. The specimens split easily, for the mica crystals of which they are chiefly composed are all oriented in the same direction.

Major Concept 1. Good soil must have enough of the minerals required for the growth of plants.

Concept 1-a, b (p. 14): (a) Minerals in the soil are consumed when plants grow.
(b) Deficiency of minerals in the soil can be made up by adding manures or fertilizers.

To show that minerals in the soil are consumed when plants grow, do this experiment.

Pull out carefully a mustard or any other plant from the soil and allow the plant to dry up in air. Cut the plant into bits and heat the bits in an iron pan till the material is converted into ash.

Now list all the elements which go to make up a plant body. We know from studies that scientists have made, that the following 16 elements are present in plants—C, O, H, N, K, P, Ca, Mg, S, Fe, B, Zn, Mn, Mo, Cl and Cu. When a plant is dried, water escapes. What elements does water represent? When the plant is burnt CO_2 and H_2O are lost. Now what are the elements left in the ash?

A plant gets CO_2 from the air and water from the soil. These escape into the air when the plant material is converted into ash. From where do you think a plant obtains the rest of the minerals represented by the ash?

Study Table II–3.

Observe a farm land or a field being made ready for sowing. Visit a nearby field. What are the mounds of dark substance, looking like dirt and refuse that a farmer has piled up in this field? Why is the farmer adding this to his soil? Take a handful and examine to see how it feels and what it consists of. This material is called *compost*.

Put a handful of the compost in a tumbler of water. Shake well and allow it to settle. What do you find floating on the surface? What is the proportion of this to the total?

Find out how this compost is made and what are its chief components. Is it organic or inorganic material? (Refer to Unit IX, Concept 1-a, Class VIII).

Make a study of how wastes of various kinds are turned into manures.

Sometimes the farmer buys some chemicals to be added to his soil. What are these chemicals? What is the need for them? What are the prin-

TABLE II–3. ESSENTIAL ELEMENTS A PLANT NEEDS AND WHERE IT GETS THEM FROM

From air and water	From the soil		
	Nutrient elements		Trace elements
C (Carbon) H (Hydrogen) O (Oxygen)	N (Nitrogen) P (Phosphorus) K (Potassium)	Ca (Calcium) Mg (Magnesium) S (Sulphur)	Fe (Iron) Sn (Zinc) B (Boron) Cu (Copper) Mn (Manganese) Mo (Molybdenum) Cl (Chlorine)

cipal elements in these ? Find out the names of fertilizers used in your neighbourhood. Find out how the Agricultural Department and the Block Development Office help the farmer in getting fertilizers.

Visit an Agricultural Officer's store. See how fertilizer bags are stored. On some you may find the word 'Balanced N. P. K. manures'. What do these letters of the alphabet mean ?

Concept 1-c (p. 14): Rotation of crops conserves minerals in the soil.

Do farmers in your area plant their crops in rotation ? Write out a list of the crops they plant and the order in which they plant them.

Why is it bad for the soil, if we raise the same crop every year on the same field ?

Why is it good for the soil if we grow a different crop each year ?

Suppose there were 3 farmers and each one grew the crop in his field in this manner. Farmer A grew only maize year after year. Farmer B grew maize, peas, beans and potatoes all mixed together. He grew the same crops every year. Farmer C divided his field into 3 plots, and grew crops as shown in plots I, II and III.

	Plot I	Plot II	Plot III
1st year	Peas and Beans	Maize	Potatoes
2nd year	Potatoes	Peas & Beans	Maize
3rd year	Maize	Potatoes	Peas and Beans

Which of the farmers will get the best harvest ? What does this experiment show ?

Farmer C gets the best harvest. Growing the same crop every year makes the soil poor in some elements. By growing different crops different proportions of elements are drawn from the soil. To see how legumes such as peas and beans affect the minerals present in the soil, see Fig. IX.24.

Major Concept 2. Soils in regions of heavy rainfall are usually deficient in mineral salts.

Concept 2-a. (p. 14): Mineral salts which plants can use are soluble in water.

To show that mineral salts which plants can use are soluble in water, take a handful of garden soil and mix it with a ½ litre of water. Thoroughly shake this mixture. Filter the water through filter paper. Take the filtered water in a beaker or aluminium dish and boil the water over a spirit lamp. Let all the water evaporate. What do you find left in the dish ? Do you find some white sediment ? What is this and where did it come from ? Infer that the sediment represents salts in the solution which came from the soil stirred in the water.

Fig. II.12. Garden soil in water.

Dig the soil up to 1 foot deep. Take out the dug-up soil. How does the soil below feel? Is it dry or is it moist?

Look at the picture of root hairs surrounded by soil particles, very much magnified. How does the root hair get its water? Is there moisture around the soil particles?

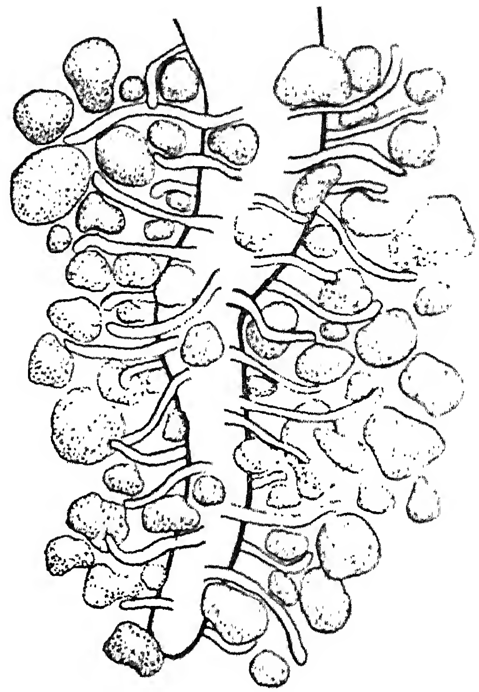


Fig. II.13. Root hairs among soil particles.

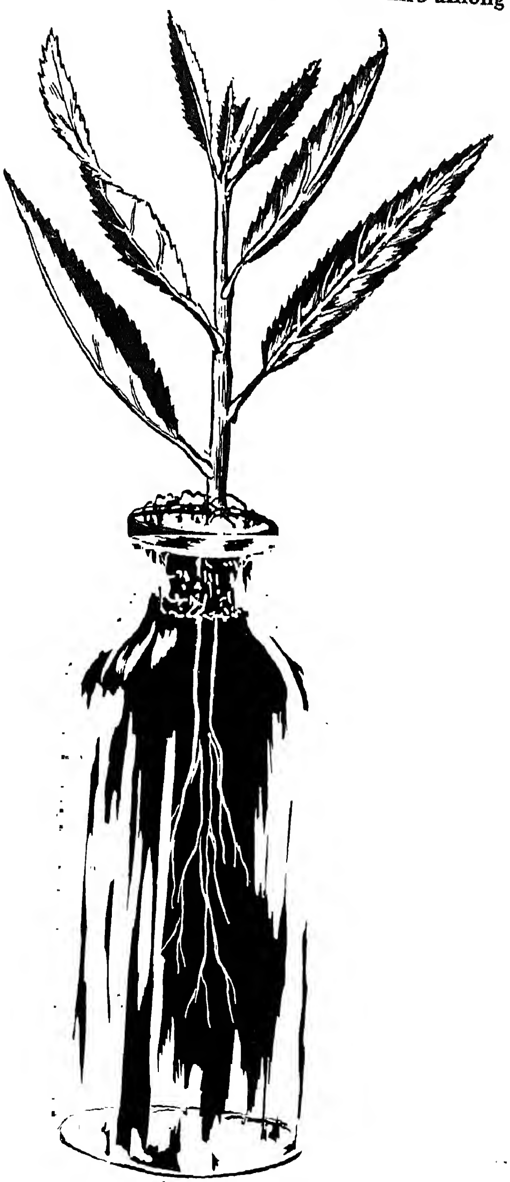


Fig. II.14. Balsam plant in water.

Grow a balsam seedling in a bottle with a nutrient solution (Knop's solution*). Pass the seedling through cotton and then plug the bottle with cotton wool. Enclose the bottle with black paper. Place the bottle in good sunlight. Watch the plant for a few days. Does it grow and produce more leaves?

---

* Knop's Solution:

Distilled water	1000 ml.
Ammonium nitrate	0.2 g
Calcium chloride	0.1 g
Potassium acid phosphate	0.1 g
Magnesium sulphate	0.1 g
Iron chloride	Trace

Concept 2-b (p. 15): Where rainfall is heavy, these mineral salts may be dissolved in the water, carried down through the soil and away towards the ocean in underground movement of water.

Watch the garden when there is heavy rainfall. Do you see how the water flows along the surface carrying some mud ? After the rains, dig up a pit to see how deep the water has soaked in.

Collect some garden soil and dry it. Take an empty tin and make a few holes in it. Put the dry garden soil in the tin. Pour water in the soil little by little. Keep on pouring till water begins to drip from the holes below. Collect a fair quantity of the water in a glass. Filter this water and heat the filtered water in an enamel vessel till all the water is driven off. What do you find at the bottom ? Infer, what happens when rain water soaks through the soil ? Where does all the water flow ?

Concept 2-c (p. 15): The extent of leaching may be lessened by keeping a cover crop of grass or other vegetation to hold the soil and absorb the minerals.

To show that a grass cover will lessen the extent of leaching, do this experiment.

Take two flat enamel trays or flat tins (without lids). Cut out one edge and replace with a wire netting. Fill one tray with garden soil and the other with an equal amount of sod (grass growing in soil). Place the trays on two beams of wood so that they are gently sloping. Place two other trays at the lower end of each tray. Now pour a measured quantity of water through the rose of a watering can. Pour equal quantities of water on each tray. Collect the water that comes out. See which tray allows more water to flow through it. See also by the mud in the water which tray loses more soil.

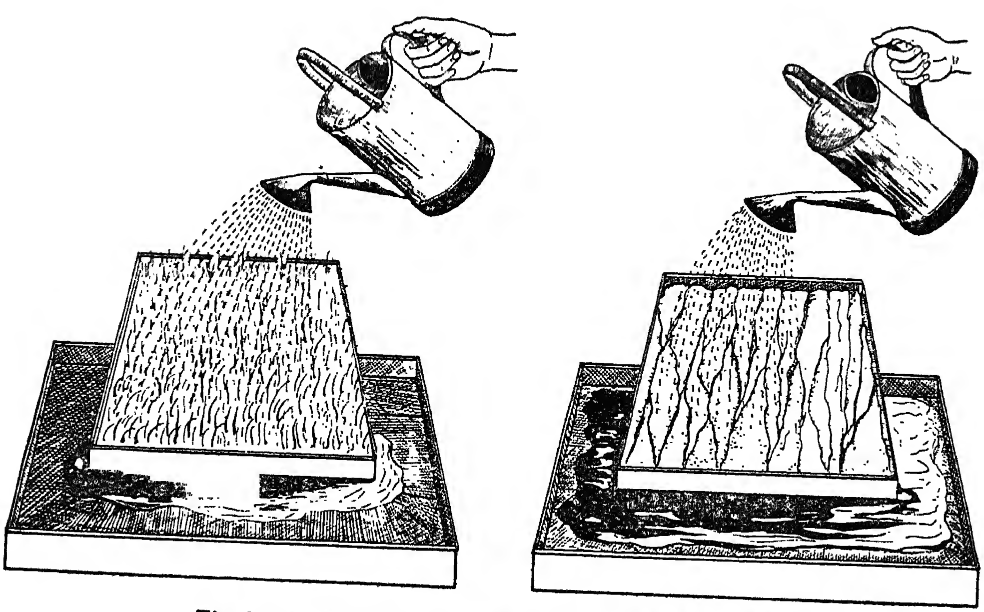


Fig. II.15. Erosion in protected and unprotected soils.

Can you see how the leaves break the fall of water ? How do leaves on plants protect the soil from erosion ? What happens to bare soil ?

Major Concept 3. Soils in arid regions may contain too much and too many mineral salts.

Concept 3-a **(p. 15)****:** With limited rainfall, the water that falls soaks into the ground, dissolves the mineral salts for some depth, and then rises to the surface by capillary action. As the water evaporates, the dissolved salts remain. Too much and too many mineral salts prevent the growth of plants.

1. Take a walk in the fields and observe the ground. In some places you may find whitish patches on the soil. Take a little of this substance in your hand and feel it. Dissolve some in water and find out whether it is soluble. How does this salt deposit come on the surface of the soil ? (It is due to evaporation of water brought up by capillary action from below.)

2. To show how the mineral salts come up to the surface of the soil by capillary action and then are deposited as a crust at the surface: Mix a cupful of salt in a can of soil. Add a little water to the top of the can. Let the water percolate down into the can. Then set the can in sunlight for several days. A crust of salt will be formed on the surface of the soil. This is how it happens in semi-arid regions.

3. To show how water rises in the capillary spaces in the soil, take a beaker of water and place in it upright a few glass tubes with bores of different diameters. Observe the water rising in them. In which tube does water rise the highest ?

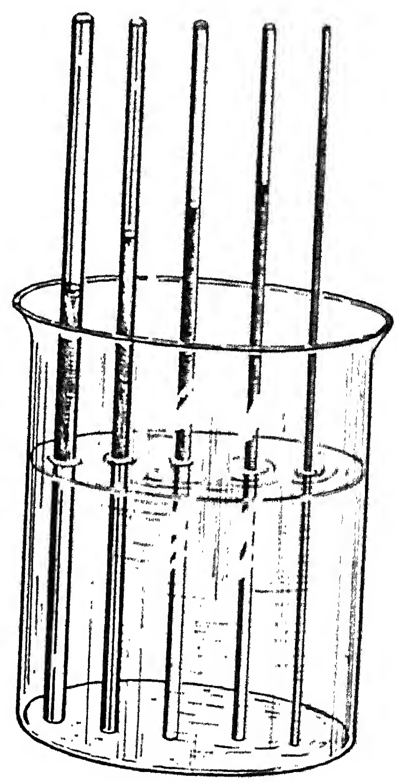


Fig. II.16. Rise of water by capillary action.

You may also show this rise of water by placing a dry brick on end in a tray of water.

4. Tie up two flat plastic scales together with the flat faces touching each other. Pour water to a level of two inches in a tumbler. Dip the scales in the beaker till they touch the bottom. Mark the initial level of water on the scales. Let the apparatus stand undisturbed for a short while.

Now remove the rulers, untie them and see the level to which the rulers are now wet. How did this water go up ? (It is through the narrow gap between the rulers.) This is an example of how water moves up narrow spaces such as pores in soil, through capillary action.

To show that too much salt stops the growth of plants, water one plant with salt water and another with fresh water. Observe the effect of the salt water on the growth of the plant.

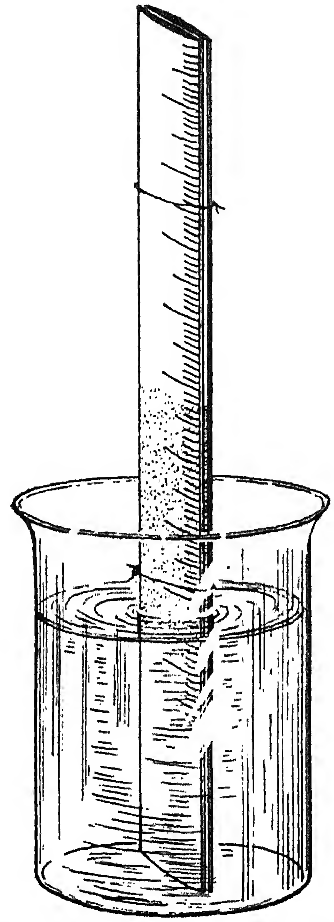


Fig. II.17. Capillary action

Concept 3-b (p. 15) : By flooding the land with water and draining off the water, excess mineral salts may be removed.

To show that the excess of salt present in a soil may be washed out of the soil by flooding the land, wash the salt out of the salted soil in the experiment in 3-a above. Drill a number of holes in the bottom of the can which is holding a mixture of salt and soil. Pour plenty of water through the soil in the can and allow the water to percolate and escape through the holes at the bottom. This takes off the excess of salt. There is one precaution to be taken. Once the salt is removed, further addition of water should be stopped to prevent leaching of minerals already present in the soil.

Major Concept 4. Irrigated soils may become 'salted'.

Concept 4-a (p. 15) : When soils are irrigated from shallow wells, the water moves down through the soil, dissolves minerals, is then pumped to the surface and used over and over again. Evaporation is probably high, and salt content of top soils increases.

To compare the mineral content of fresh rain water with that of well water which has percolated down through the soil, evaporate equal quantities of fresh rain water and water from a shallow well and compare the residues left in the dish. What conclusions do you draw ?

Discuss how water from a shallow well when used over and over again for irrigation brings the soluble salts on the surface and due to high rate of evaporation the surface soil may become salted.

Concept 4-b (p. 15): Improved methods of irrigation lessen the tendency of soils to become salty.

(i) Water from deep wells is preferable to water from shallow wells.
(ii) Water from large storage reservoirs is perferable to water from shallow wells.
(iii) Contour terracing, or the construction of simple bunds along contours makes possible equal dosage of water from irrigation ditches. By using controlled amount of water, salting is lessened.
(iv) In badly salted land, drainage ditches can be used to flush out the excess salts from the soils.
(v) Salty water may also be pumped out by tube wells and carried to rivers through lined channels.

To find out how water may be applied in many ways to lessen the tendency of the soils to become salty, read booklets and articles in papers describing improved methods of irrigation. These methods provide for an even application of just the right quantity of water at proper intervals of time.

Visit fields near your school and observe different methods of irrigation. Collect pictures of wells, canals, water wheels, bullocks and men at work. Paste them in an album. Write a sentence under each describing it.

If there are any dams or reservoirs nearby, visit them. Visit irrigation works, and observe canals, ditches and control doors by which only the regulated quantity of water is allowed.

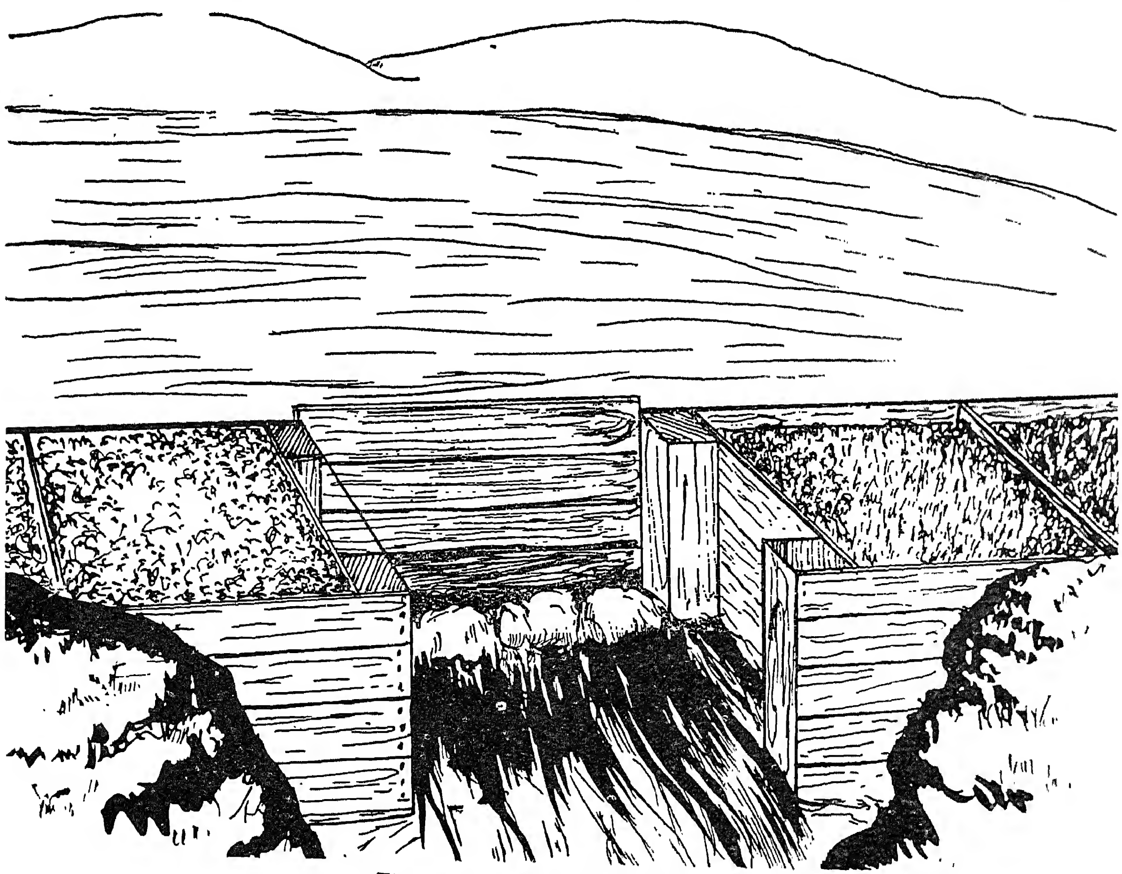


Fig. II.18. Water-gate at the bund.

See how bunds are constructed and canals are made to enable water to be distributed evenly. Canals may bring fresh water from rivers. (People near river projects can see this.) See how the canals are lined to prevent the water from getting undesirable materials from soils over which water may flow if the canals are not lined, such as that leading from Bhakra Dam.

Some gardens have deep tube wells from which water is pumped and led through canals.

Notice the contour terracing and bunds along contours. Find out various ways to remove excess salt from land where there are too many minerals in the surface soil.

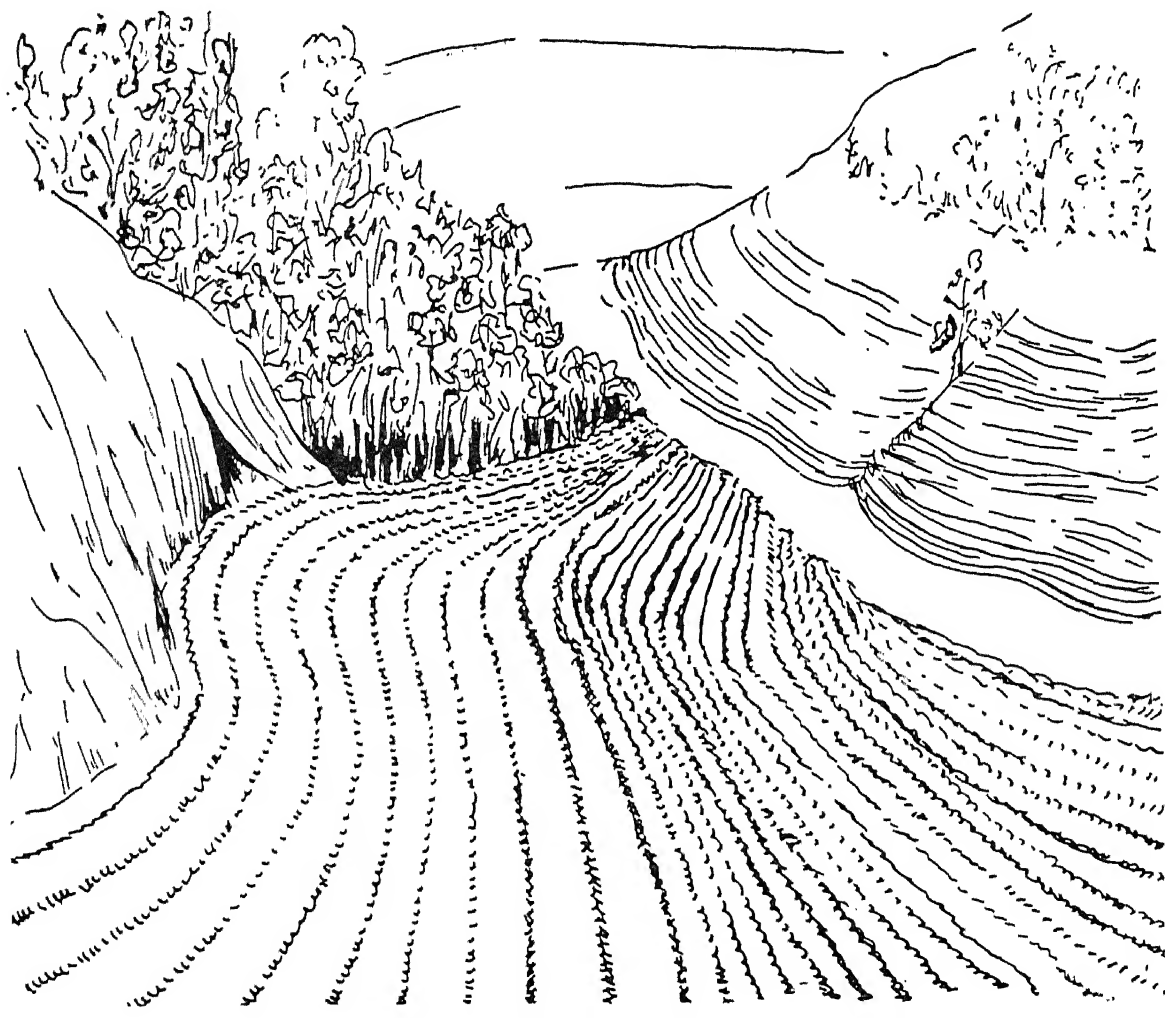


Fig. II.19. Contour furrows.

Major Concept 5. Rocks and minerals are the sources of metals and non-metals required in large quantities by industry. Minerals comprise much of the wealth of a nation.

Concept 5-a (p. 16): Some of the common rocks used commercially are:

(i) Clay which is used in brick, tile and cement.
(ii) Limestone which is used in cement, as a building stone for road ballast and for agricultural purposes.
(iii) Sand and gravel which are used in concrete for building and for roads.
(iv) Dolomite which is used for fire brick, in refining iron from ore, and for agricultural purposes.
(v) Basaltic rocks which are used for buildings and roads.

To see how common rocks are used commercially, take a trip to see how such rocks are used, in building road , in building houses, in making concrete or as additives to the soil. If there are any brick kilns or tile factories or limestone quarries, or granite quarries nearby, arrange to visit these places and find out about the way rock materials are used.

Concept 5-b (p. 16): Some of the common minerals found are:

(i) Haematite which yields iron.
(ii) Bauxite which yields aluminium.
(iii) Galena which yields lead and silver.
(iv) Tinstone (casserite) which yields tin.
(v) Chalcopyrite which yields copper.
(vi) Caliche which yields iodine.
(vii) Gypsum which yields sulphuric acid that is used in the making of fertilizer and other things.
(viii) Rock salt which yields salt, chlorine and caustic soda.
(ix) Saltpeter which yields nitrates.
(x) Monazite sand which yields radioactive metals.
(xi) Quartz from sand which is used for glass industries.

Collect, examine and read about as many of the common minerals mentioned above as possible. Find out how such minerals are mined or how they are separated from their ores.

Major Concept 6. Stores of minerals vary in abundance.

Concept 6 a, b & c (p. 16):

(a) Stores of such common rocks as clay, limestone, sand and gravel are present in adequate amounts.
(b) Stores of most metals, fuels, and some others are present in limited supply. This supply should be con erved.
(c) Coal and petroleum are chiefly obtained by mining from beneath the surface of the earth.

Find out from books and magazines about the occurrence and abundance of various minerals and fuels. Some of them are in plenty. Which are they ? Some are limited in supply. Coal

and petroleum are being used up fast. Experts say their stock may not last for ever. Collect information as to how to conserve these and to make the stock last longer. Some of these methods are (1) improving the methods of mining them from the earth, (2) discovering ways of getting metals from low grade ores, (3) avoiding waste, (4) developing substitutes, and (5) locating new deposits.

Major Concept 7. Sea water is becoming of increasing importance as a source of minerals.

Concept 7-a, b. (p. 17): (a) Materials now obtained from sea water are: salt, magnisium, bromine, and iodine.
(b) The depths of ocean are strewn with nodules that are rich in manganese, copper, cobalt, nickel and phosphorus. These will probably be mined in the future.

Find out about the dissolved minerals in seawater. What uses are made of the sea salts ?

Read articles about the minerals, present in the depth of the ocean. Articles of the findings during the 'International Geophysical Year' give you information about this subject.* (Refer to concept 3-a Unit 11)

Radiolaria) rich in lime, and diatoms rich in silica.

Shark teeth and whale ear bones are found a tthe bottom of the ocean. These are the remains of the sea animals which die. They are rich in tricalcium phosphate, a rich source for phosphate fertilizers. Phosphorite occurs on the sea bottom as slabs

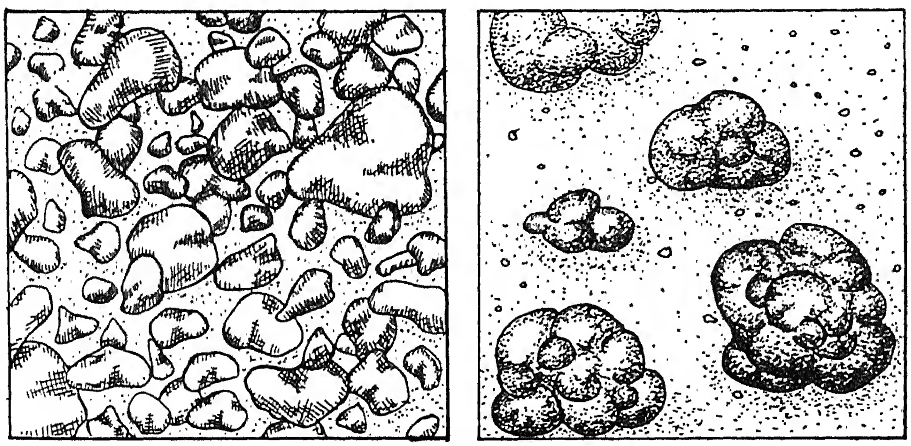


Fig. II 20. Minerals on ocean floor.

The picture above shows metallic ores in the form of lumps or nodules rich in manganese, iron, cobalt and copper. Sea floor nodules may prove to be a cheaper source of manganese, nickel, cobalt and even copper than the present sources in land.

In very deep waters are found red clay very rich in iron (rusted) dust. Besides these, there are the oozes of shells (of *Globigerina* and

and masses, another source of the important phosphate fertilizer. Commonly found in the sediments are nickel-iron spherules. They are magnetic.

Certain sea animals extract elements from sea water and concentrate them in various parts of their bodies. Some skeletal remains of fish contain zinc, copper, tin and rare earth elements. Nickel and silver are also concentrated in the bones of fishes.

* MERO J.L. Minerals on the Ocean Floor, *Scientific American*, December, 1960.

UNIT III Human Body, Health & Hygiene

CLASS VI

Major Concept 1. Man needs food to grow and to work.

Concept 1-a (p 27): Food gives energy to move and do work.

Tell the pupils, lunch time is a favourite time of the day. Why is this so?

List on the blackboard all the reasons pupils give for eating, such as for enjoyment, stopping hunger, for growth, for health. Expand these ideas with the examples given by pupils. Perhaps they have gone without food for a day. Do they wish to race about? Do they have as much energy? Are they listless or inattentive in class?

One way to be sure that you get an adequate diet is to eat a variety of foods. List all the foods you have never tasted. Try a new one and tell your reaction.

Concept 1-b,c (p.27): (b) Food is essential for growth.
(c) When we work, some parts of our body are worn out. The worn out parts are replaced by food.

Find out the causes of malnutrition. Perhaps you can interview a doctor or a health-worker on this.

Major Concept 2. Different types of food cater to different needs of the body.

Concept 2-a (p.27): Some foods provide energy and may be called fuel foods.

1. Sugar, cereals, potato, pulses and many vegetables contain carbohydrates which supply heat and energy to the body.
2. Ghee, butter, oils, dry nuts, etc., contain fats which also supply energy.

1. Keep a record of the meals that you take in a day including any lunches or beverages. How many food groups were in your meals today?

TABLE III—1. BASIC FOOD GUIDE

Nutrients	Things they do	Where you find them
Carbohydrates	furnish energy	cereals, (rice, wheat, etc.) sugar, pulses, many vegetables such as potatoes.
Fats	furnish energy (rich source) and lubricates the large intestines.	ghee, butter, oils, milk, nuts, eggs (yolk), fat of meats.
Proteins	build body, repair worn out parts. Also furnish energy.	pulses, peas, beans, eggs, milk, cheese, sea-foods, poultry, meat, peanuts, soybeans.
Minerals	build bones and teeth. Iron is needed for blood to deliver oxygen to cells.	milk, green vegetables, dried fruits, eggs, liver, shell-fish, whole cereals.
Vitamins	keep body regulated; help keep eyes, skin and gums in good condition.	fruits, vegetables, eggs, milk, lean meat, fish liver.
Water	makes up much of the body.	drinking water, beverages, nearly all foods.

Ask yourself these questions. What good source of protein did I have today? What good source of minerals? of carbohydrates? of fats?

2. Rub a nut such as a cashew nut or peanut on a piece of brown paper or writing paper. Then hold the paper up to the light. What do you notice? Would you say there is fat in these nuts? Test several other kinds of foods. Try a piece of potato and then try a piece of cheese. Do they give the same results? Test a wide variety of foods and make a chart of the results.

3. We say some foods act as fuels. Do you believe this? Melt some ghee or butter in an old spoon. Place a string in the fat to act as a wick. Light the wick. What happens?

4. The heat energy in foods may be shown by burning some peanuts in an evaporating dish or some adequate container and placing some water in a spoon or beaker above the burning peanuts. If the temperature of the water is taken, the heat can be demonstrated.

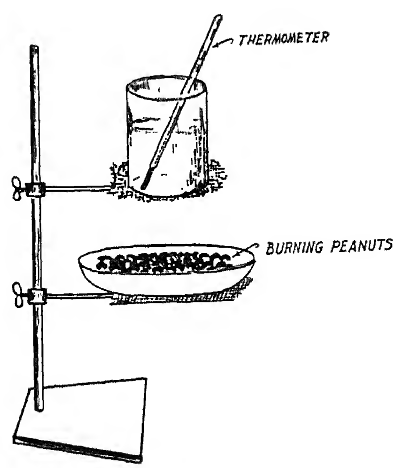


Fig. III.1. Foods are fuels.

Concept 2-b (p.27): Some foods build the body and repair the worn out parts. These are called proteins. Meat, eggs, milk, pulses, peas, beans and fish are protein foods. These also furnish energy.

1. Burn a feather in a flame. Note the smell. This is a characteristic of burning protein, one of the basic nutrients in foods.

Now hold a piece of cheese over a flame by means of a long needle or a pair of forceps. Is the smell like that of the burnt feather? Burn the following foods to see if they give the same smell: white of egg, peas, pulses, milk, beans.

2. See if you can find a book that lists the amount of protein in different foods. What is the cost of each? How much protein is there in a half cup of cheese? You can compare other proteins and make a chart of your results.

3. Plan an experiment to test this idea: If you eat a meal of proteins, you will not get as hungry as you would if you had eaten all carbohydrates.

Concept 2-c(p.27): Certain foods contain minerals and salts which are required in small amounts for proper growth and body building:

1. Calcium is needed for building bones and teeth.
2. Iron is needed for red blood cells.
3. Phosphorus is needed for bones, nerves and body growth.
4. Iodine is needed for balanced growth.

Milk, fish, meat, fruits, green vegetables, eggs, and whole cereals supply minerals and salts.

1. Take a Bunsen burner or a spirit lamp. Fix a support and place a piece of wire screen over the flame. On the screen place some green leafy vegetable cut into shreds. If you heat these long enough only the minerals in them will be left. Test some other vegetables in a like manner. Test like amounts of two kinds of vegetables. Are your results the same? Write down what you find out.

2. Some of you may wish to weigh the green vegetable before burning and again weigh the ash after burning. The water content can be determined in this way.

3. Is there a shortage of iodine in your region? Find out what iodine does for the body. Is there a way to add iodine to your diet? (Check on sea-foods and iodized salt).

TABLE III—2. ESSENTIAL MINERAL SALTS IN THE DIET

	Essential for	Source
Calcium	building bones and teeth, heart and nerve action, clotting of blood.	milk, whole-grain cereals, fish, lettuce, cheese, oranges, nuts.
Phosphorus	building bones and teeth, formation of protoplasm.	milk, whole-grain cereals, fish, cheese, egg yolk.
Iron	essential constituent of haemoglobin of red blood corpuscles.	lettuce, leafy vegetables, liver, eggs, fresh tomatoes, carrots, fresh lima beans and peas, lean meat, nuts.
Iodine	essential constituent of thyroxin in thyroid gland.	sea-foods, iodized salt, some water, many foods except in several regions.

4. Some important aspects of mineral need can be brought out by discussion. A new born baby is rich in iron, but relatively poor in calcium. The skeleton, composed largely of calcium and phosphorus, gets most of its growth in the first eighteen years of life. Nearly one third of the phosphorus found in the body is in the muscles and other soft tissues, which also develop rapidly during the first years of life. Growing children require relatively more calcium and phosphorus. Iron is so essential in respiratory processes that it must not be neglected in the diet.

Concept 2-d **(p.27-28)****:** Some foods contain small amounts of substances called vitamins which are needed for body growth, resistance from diseases and prevention of certain diseases. Vitamins are obtained from milk, eggs, whole-grain cereals, green vegetables, fish liver, fresh fruits and from artificial sources.

1. Vitamin A is required for building the body, healthy skin and good eyesight. Its deficiency leads to night blindness and lowers the resistance to infection. It is obtained from leafy, green and yellow vegetables, whole milk, butter, eggs, liver and kidney.
2. Vitamin B is required for the health of the skin, proper functioning of nervous system and for helping growth. Its deficiency leads to beriberi, anaemia and pellagra. It is obtained from milk, meat, liver, whole-grain cereals, whole-grain bread, yeast, eggs, green peas and peanuts.
3. Vitamin C is required for good bones, teeth and gums. Its deficiency leads to scurvy, bleeding gums and tendency to bruises. It is obtained from citrus fruits (lemons, oranges) guavas, mangoes, apples, tomatoes and green vegetables. This vitamin is readily destroyed by cooking.
4. Vitamin D is required for building good bones and teeth. Its deficiency causes rickets. Exposure to sunlight enables the body to build this vitamin. It is obtained from fish liver-oils, milk, eggs and some fish.

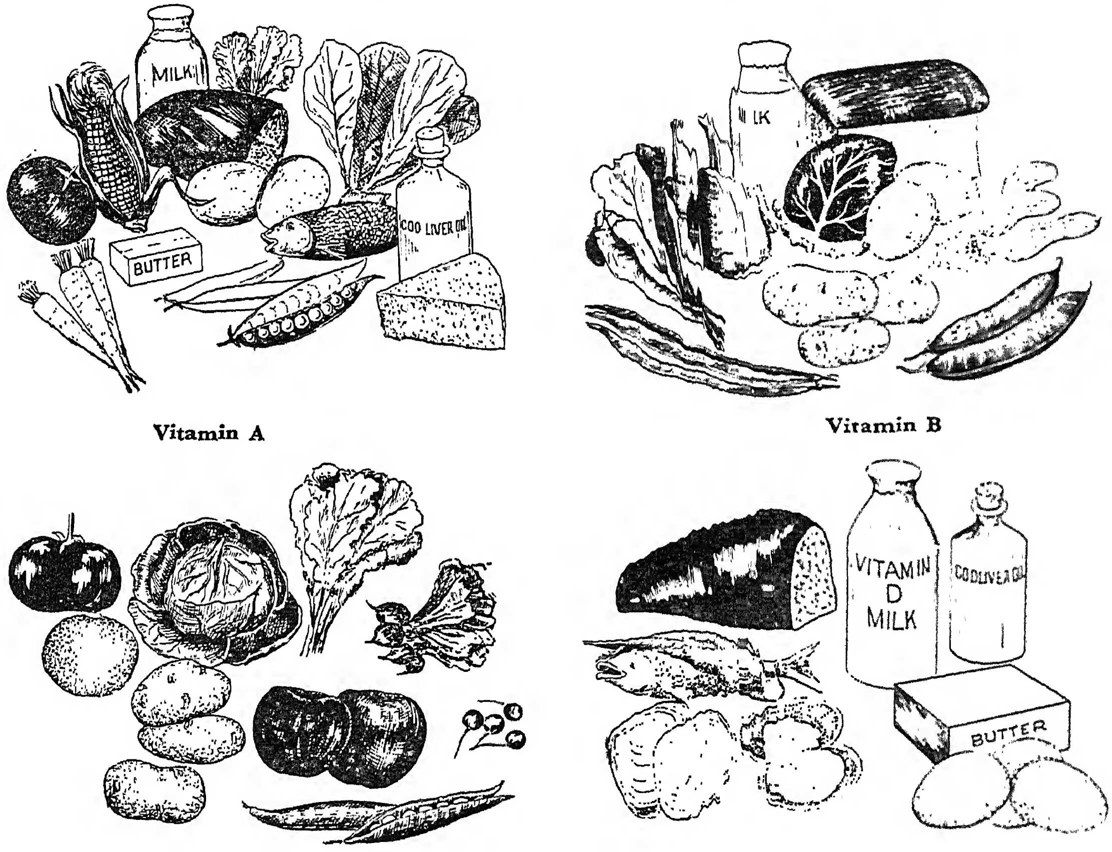
1. Study the vitamin chart and see if your diet contains these essential nutrients.

TABLE III—3. VITAMINS, THEIR OCCURRENCE AND USES

Vitamins	Sources	Uses
A	yellow vegetables, green leafy vegetables, egg yolk, butter, ghee, cheese, milk, curds, liver.	Helps build the body. Keeps eyes and skin healthy.
B	green peas and beans, pulses, poultry, liver, green leafy vegetables, eggs, whole grains, peanuts, yeast, lean meat.	Keeps nervous system healthy. Helps build body tissues. Prevents anaemia, beri beri, pellagra.
C	tomatoes, oranges, grapefruit, lemons, limes, cabbage, green chillies, new potatoes.	Keeps mouth, gum, and teeth healthy. Keeps blood vessels in tone. Prevents scurvy. (Cannot be stored in body and hence must be eaten daily.)
D	fish oils, eggs. Sunshine helps the body make Vitamin D.	Needed for proper bone formation. Prevents rickets.

2. Read more about vitamins, how they were discovered, and how scientists are learning more about them and where they are found. Find out the meanings of the following words: rickets, beri beri, pellagra, scurvy, anaemia. Some men you may wish to read about are: Eijkman, Goldberger, Lind, McCollum, Funk. Make a report on one of these men for your class.

3. Some of you may wish to find out about the B group of vitamins in particular, or to locate information about vitamins E and K.



Vitamin A

Vitamin B

Vitamin C

Vitamin D

Fig. III.2. Sources of Vitamins A, B, C and D.

Major Concept 3. Quantity of energy giving and body-building foods must be sufficient for the needs of the body.

Concept 3-a (p. 28): Growing children require more body-building materials.

Human beings, like all other animals, grow. As they grow, processes going on within the cells of their body convert some of the food they eat into living tissues. The faster they grow, the more body-building foods are required. Men and women usually gain adult size during the first eighteen years of their life. After adult size is attained, body-building foods are still needed to replace worn-out tissues or to heal a wound but such foods are not required for growth as in the case of the young child.

Figure III-3 a shows the pounds gained during different years of childhood. The gain is exceptionally rapid during the first year and again during adolescence. A baby which weighs eight pounds at birth will gain from 13 to 14 pounds during the first year—more than doubling its weight. But a boy or girl of 19 years of age will

gain on the average about a pound in weight. Of the years shown in the graph at what age do girls make the greatest gain in weight? When do boys make the greatest gain in weight? Which group makes the greater gains during the seventh year? The seventeenth year? Have you noticed that girls of 13 and 14 years of age are larger than boys of the same age? By looking at figure 13 tell why this is so. The boys, however, overtake them during the fifteenth year and get progressively farther ahead during the fifteenth to the eighteenth year.

In the following statements, see if the first mentioned person requires more or less of the body-building foods than the second person. Fill in the blank with the appropriate word (i.e., 'more' or 'less').

(a) A six-year old boy requires.......... body building food than a 30-year old man.

(b) A fifteen-year old boy requires.......... body building foods than a one-year old child.

Make some other comparisons. Compare your answers with those of your classmates. Can you tell why your answers are correct ?

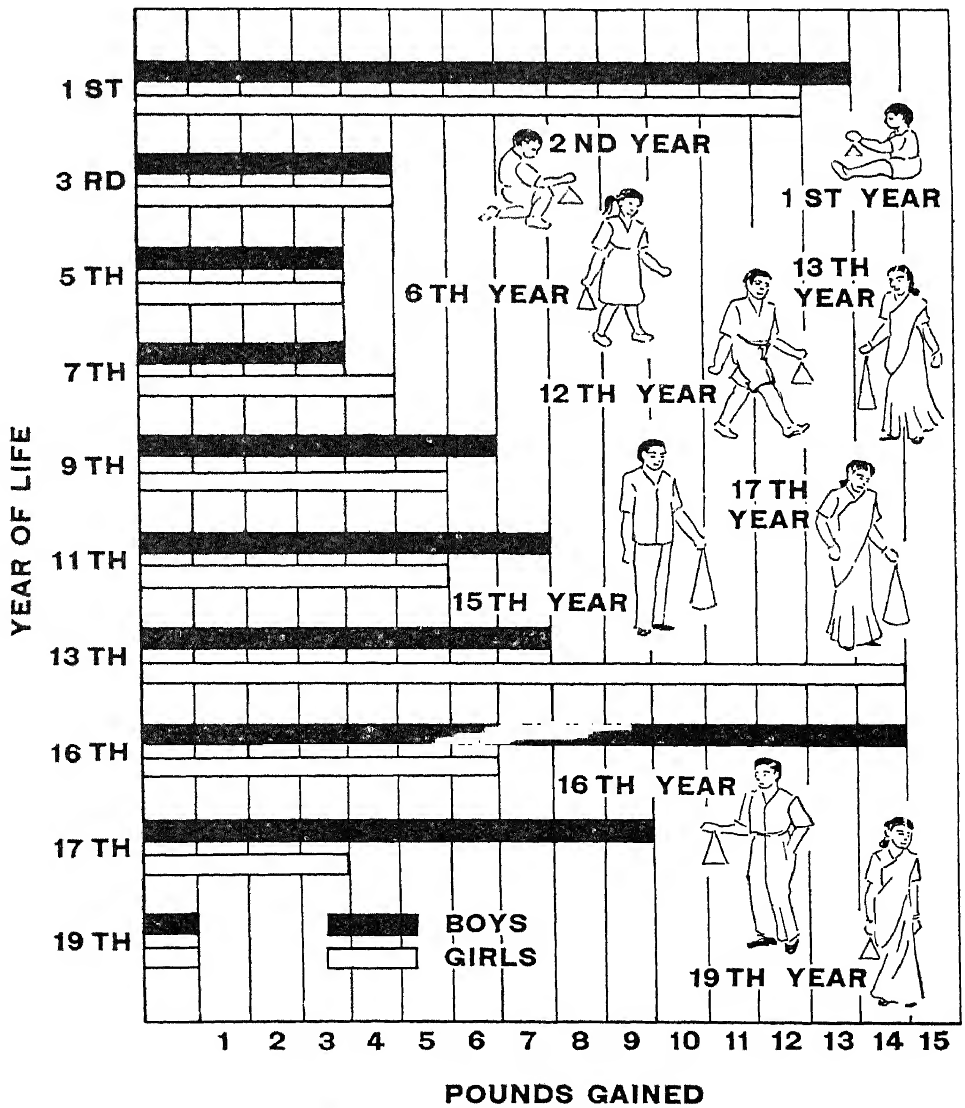


Fig. III.3a. Energy needs vary with age and sex.

Figure III.3 b shows the average daily expenditure per pound of body weight for boys and girls of different ages. The graph shows clearly that the energy needs of children per pound of body weight, decreases with age and also that it is somewhat different for boys than for girls. One reason that girls and women require less energy per pound of body weight than do boys and men is that they have a slightly thicker layer of fat beneath the skin than boys and men. This layer lessens the rapid radiation of heat from the body. Also, they are usually more curved and less angular in shape and so expose less surface per pound of body weight than do the boys and men. It is interesting to note that most of the long-distance swimming records are held by women rather than by men. Their bodies do not lose heat to the water as rapidly as is the case with the boys and men.

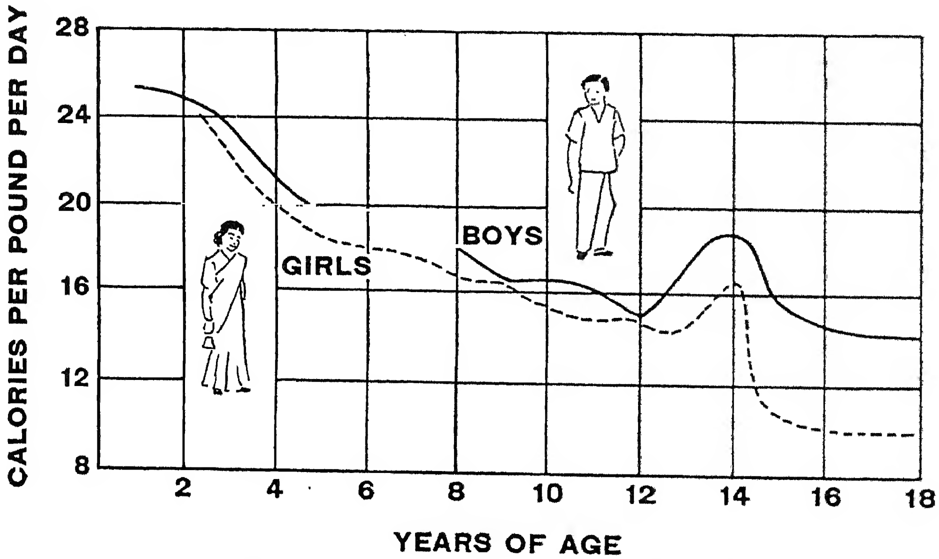


Fig. III.3b. Energy needs vary with age and sex.

From experience you know that the body loses heat faster in a cold climate than in a warm climate; when one has few clothes than when one is wrapped up in warm clothes. Clothing and shelter are factors which affect the loss of heat from the body. And the warmth of the body comes from the oxidation within the body of some of the food one has eaten. From Fig. III.3b. you have seen that as boys and girls become older they require less energy per pound of body weight. Why is this so? As they become older they also become heavier, don't they? But will they lose as much heat from the surface per pound of body weight as when they were smaller? It is from the surface that heat is lost from the body, and of course, the more surface that is exposed the greater will be the loss per pound of body weight.

Look at Fig. III.4. This figure shows that surface depends upon size and shape. Both men are drawn to represent the same weight, but the tall man has more surface from which to lose heat, doesn't he. The eight babies taken together are supposed to weigh the same as each man. But you can see that their surface is greater than that of either men. Why is this so? Look at the cubes at the top of the illustration for your answer. Let us suppose that each cube represents the volume of material in the body of one child. Each cube is 1 cm. square on a side. Each cubic centimeter exposes 6 square centimeters of surface in the case of the babies. All eight cubes, representing eight babies may be said to have 8 cubic inches volume, and to expose 48 square centimeters of surface. In this case the ratio of the surface to the volume is as 48/8 or 6/1.

But when these same eight cubes are piled on top of each other in a way to represent the tall person then there is less surface exposed than

when they are all separate. Count the square centimeters of surface in this case. It is 34/8 or slightly over 4/1.

In the case of the eight cubes piled together to form a single large cube, which represents the same volume of material as arranged in the fat man, the ratio is 24/8 or 3/1. So you see the fat man has much less surface exposed from which to lose his body heat than the tall man, and a great deal less than the eight babies. It is this basic relationship of surface to size that makes a big difference in the energy needs of different people. Weight is closely related to size. Now the reason why energy needs during childhood

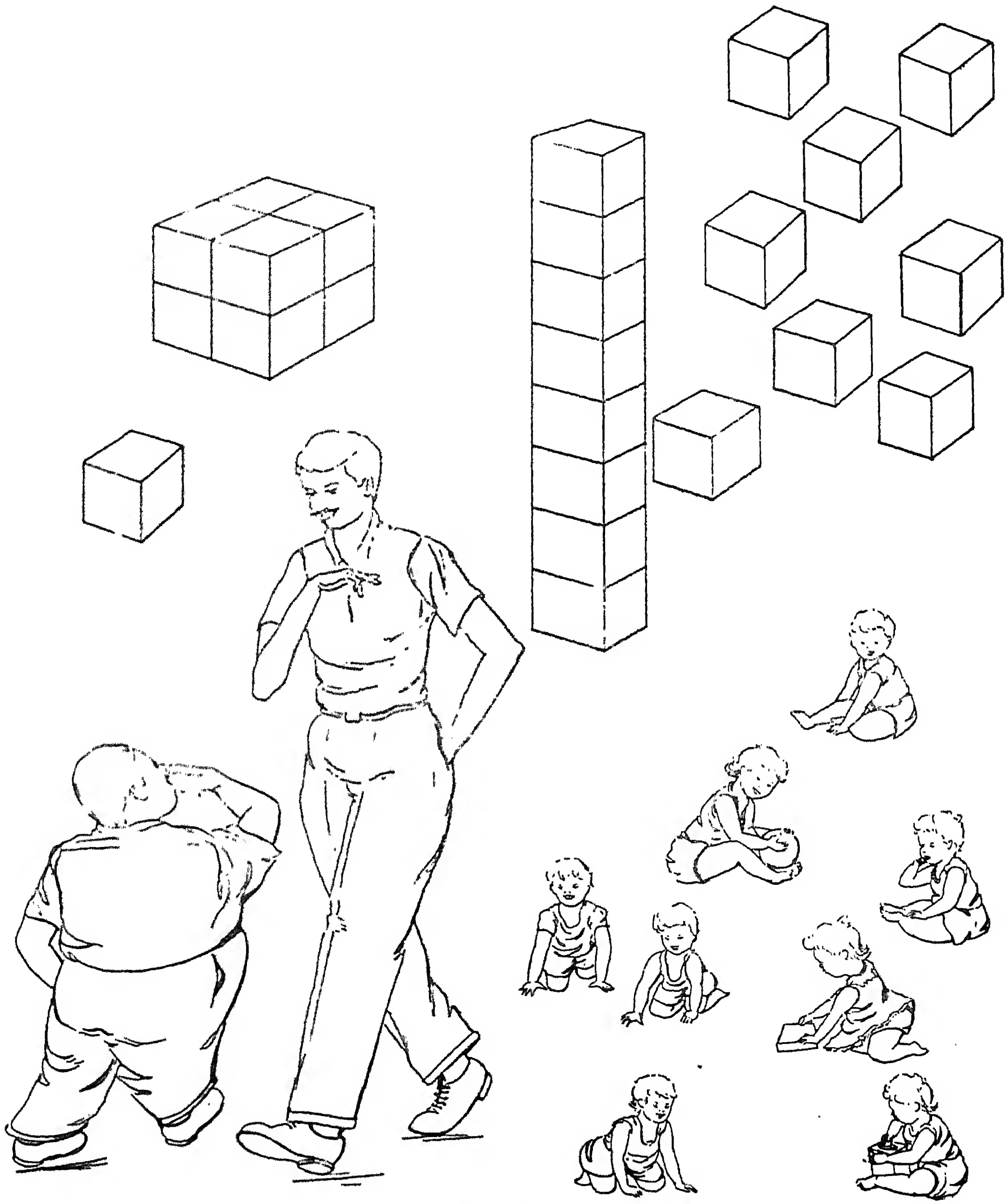


Fig. III.4. Energy needs vary with weight.

decrease with age should be clear. As weight increases there is less loss of heat per pound of body weight. In Fig. III.3b, explain why the curve is higher at 14 years of age than at 12 years of age.

Concept 3-b (p. 28): Manual workers require more carbohydrates and fats.

Up to this point nothing has been said about the effect of activity upon one's energy needs. But each of you, no doubt, know from your own experience that you require more food when you are playing hard, or doing heavy physical work. Foods are used to produce energy to contract muscles and to do work. Thus we can speak of the energy cost of activities. Fig. III.5 (p.67) is a pictorial representation of the energy cost of different activities. The size of the circles represent the energy required for each activity. The boy lying down is relaxed and spending very little energy over and above his basic needs. But notice that as the rate of movement increases that the energy cost of activity goes up. The boy walking is spending more energy than the one sitting still, the boy running still more, the one swimming still more, and the one running up the stairs more than any of the rest. Have you noticed that you get short of breath as you engage in vigorous exercise? This is because you are spending energy faster and so need more oxygen from the air to release that energy.

TABLE III-4. CALORIE REQUIREMENTS VARY WITH ACTIVITIES

Activity	Calories/lb./hour
Sleeping	0.43
Si ting still	0.65
Standing	0.74
Bicycle riding (moderate speed)	1.59
Fast walking	1.95
Dancing	2.18
Swimming	3.25
Running	3.33

Measurements have been made of the energy expenditure of activities and tabulated in terms of calories of energy per pound of body weight per hour. A calorie is the quantity of heat required to raise the temperature of one litre of water through one degree centigrade. This is a basic unit used in calculating energy requirements of the body. Dietitians plan meals in terms of their caloric value, and in terms of the number of calories needed by the persons who will eat the food. Rapidly growing adolescents require more food per pound of body weight than do adults. Likewise, sportsmen or manual labourers require more than do those who sit at a desk. Table III-4 shows the energy expenditure of various activities. This energy expenditure is over and above the basic energy needs of the body.

But even though one is "doing nothing", the body is using energy to keep warm and to carry on normal metabolic processes. The heart is pumping the blood round and round within the body. Muscles are moving the chest and abdomen as one breathes. Growth is taking place. Worn-out cells are being discarded and new ones are being formed, especially blood cells. This basic requirement of energy of children is shown in the following table. The figures are given in terms of calories needed per pound of body weight. It is somewhat different for boys than for girls. Also it varies somewhat with age. Account for these differences in terms of what you have learnt from the above figures and tables.

Given below are statements about people with different activities. The first needs more or less energy giving foods than the second. Write in the blanks 'more' if more is required; and 'less' if less is required.

(a) A student at school requires............ energy giving food than a person of the same age, weight, and sex, training for tennis.

(b) A bicycle rickshaw puller requires...... energy giving food than an office clerk of the same age, weight and sex.

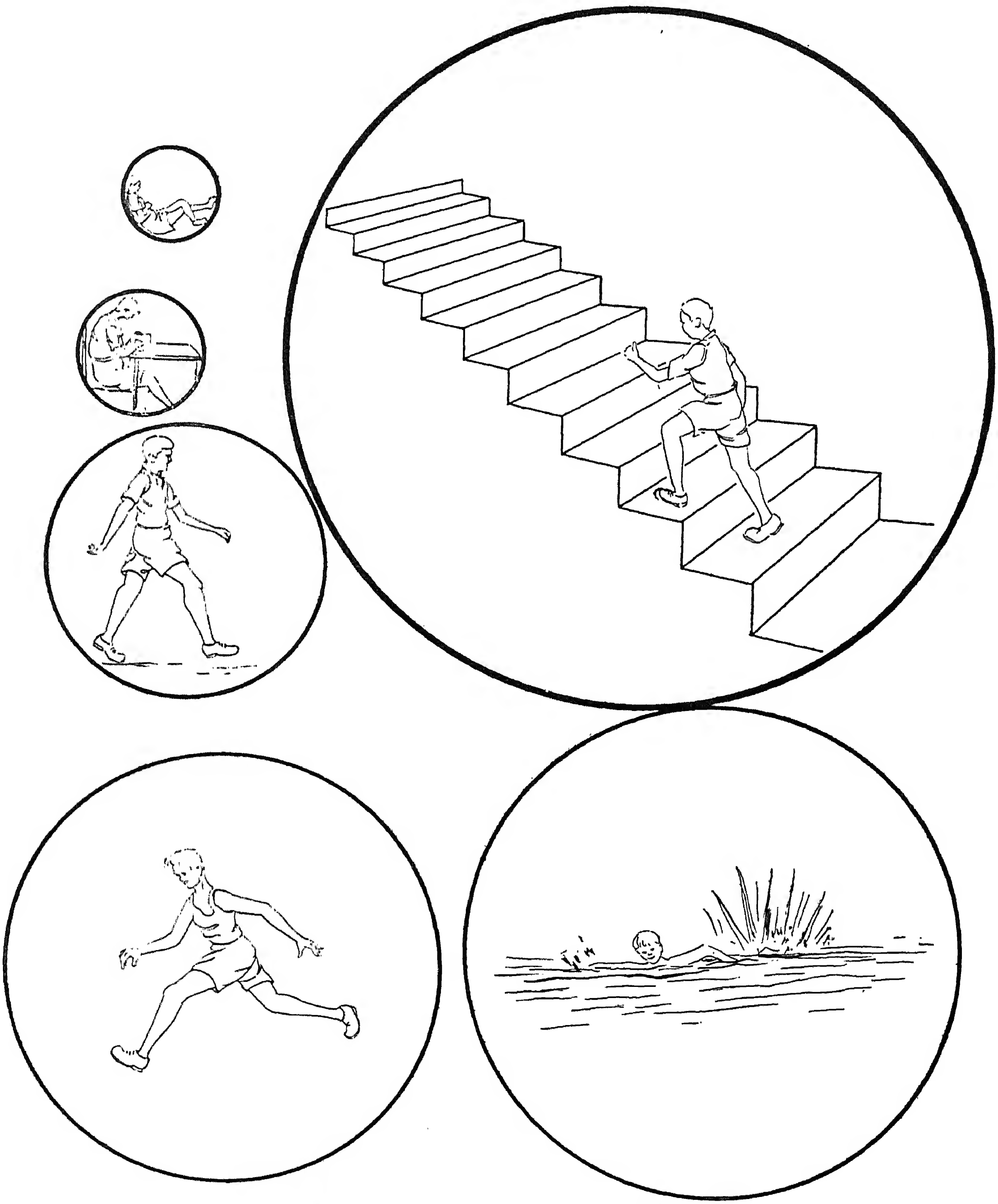


Fig. III. 5. Energy needs vary with activities.

TABLE III–5. BASIC ENERGY NEEDS OF CHILDREN IN TERMS OF BODY WEIGHT

Age in years	Calories needed per lb. of body weight of boys	Calories needed per lb. of body weight of girls
1	25	25
2	25	25
3	23	22
4	21	20
5	20	19
6	20	18
7	19	18
8	18	17
9	17	17
10	17	16
11	16	15
12	15	15
13	18	14
14	19	17
15	16	11
16	15	10
17	14	10

Concept 3-c (p. 29): Sportsmen and athletes need foods which supply energy quickly.

TABLE III–6. AVERAGE DAILY CALORIE NEEDS

Child under 2 years	1000	Calories
Child from 2 to 5 years	1300	,,
Child from 5 to 9 years	1700	,,
Child from 10 to 12 years	2000	,,
Girls from 12 to 14 years	2200	,,
Boys from 12 to 14 years	2600	,,
Girl from 15 to 18 years	2600	,,
Boy from 15 to 18 years	3000	,,
Man doing moderate work	3200	,,
Man doing hard work	3500-4500	,,
Man doing heavy labour	4500—5000	,,
Man doing very heavy labour in extremes of temperature.	5000-8000	,,

In the above table are shown the average number of calories needed by people of different ages and doing different activities. Certain sports like football require many calories, as these men do hard work. About how many calories should you have per day?

1. Draw some charts for your room illustrating what you have found out about the food needs of growing children. Then, illustrate the needs of athletes in relation to people with sedentary habits. Who would need more energy-giving foods, a school teacher or a distance runner ?

2. Look on the accompanying charts and determine your average daily calorie requirement. You will need to know your body weight and your daily activities.

Heat energy is measured in calories. A calorie is the amount of heat needed to raise one gramme of water through one degree centigrade. Energy needs of the body are given in calories. Needs depend on age, weight and activities of the individual.

Concept 3-d (p. 29) : Vitamins of the right type are needed for normal growth and for the prevention of deficiency diseases.

A test for vitamins helps in understanding that they are really chemicals. To test for vitamin C, use ordinary iodine diluted with 100 parts of water. Dilute one drop of 10% ascorbic acid (obtained from the chemist) with 20 drops of water. Add diluted iodine. The brown colour disappears completely, leaving the liquid clear. The more vitamin C in the substance tested, the quicker the iodine colour disappears. Try testing orange, lemon or tomato juice. Test some other foods also by this method.

Dramatize some of the episodes in the discovery of vitamins and how they cured deficiency diseases, e.g., the story of the Japanese soldiers and their diet resulting in pellagra, and how a diet of whole-grain rice helped.

TABLE III—7. VITAMIN DEFICIENCY DISEASES

Rickets	Bones become very soft, in a deformed condition.	Vitamin D—the sunlight chemical also found in fish-liver oil, egg yolk, some in milk.
Beri-beri	Nerve inflammation leading to paralysis and limbs.	Vitamin B—in liver, pork, milk, whole-grain, green, leafy vegetables.
Scurvy	Bleeding gums, sore and swollen joints.	Vitamin C of citrus fruits, tomatoes, cabbage.
Pellagra	Skin disorder, inflammed mouth parts, severe digestive disorder.	Niacin component of vitamin B in whole, grains fish, green vegetables, liver.

Major Concept 4. Food has to be digested before it can be absorbed and assimilated.

Concept 4-a, b (p. 29) : (a) Most food is really in an insoluble form.
(b) When the food is converted into a soluble form, it can pass through the walls of the digestive organs into the blood system. This conversion into soluble form is digestion.

Have you ever seen a cell under a microscope ? Perhaps your school has a microscope and this will be possible. Most cells are very small.

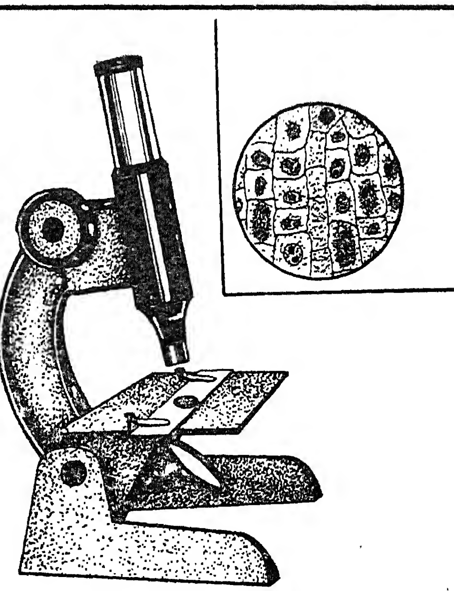


Fig. III.6. Cells seen under microscope.

Do you know how the *chappati* you eat gets into the cells to give you energy or build your body ?

1. Dissolve a teaspoonful of corn starch in water. Dissolve a teaspoonful of sugar in an equal amount of water. Which can be taken up by the blood more easily ?

2. Chew very thoroughly either a small piece of dry bread or a piece of raw potato. Does it taste sweet after a time ? With the digestive juice, saliva, the starch of the bread or potato has been broken down into sugar.

3. To show how the sugar is dissolved and gets from the digestive organs into the blood system, take a potato and cut it into very thin slices. How does it feel ? (soft and limp). Place it in clear water for an hour or so. Examine it again and observe that the slices have absorbed large amounts of water and become rigid. Dissolved food passes from the digestive organs into the blood in somewhat the same manner as water passes through cell membranes into the potato slices.

4. To determine which of the food substances passes through (diffuses through) membranes, place a dilute solution each of starch paste, molasses, olive oil and the white of an egg in four wide-mouthed bottles. Tie a cellophane or a bladder membrane which can be procured from a meat market, tightly over the tops of the bottles and suspend each in a jar of water overnight. In which of the jars of water has a change occurred ? What conclusions do you draw ?

If a thistle funnel is available, the experiment can be set up as in the illustration.

Observe what happens to the level of the liquid in the steam of the tube after several hours. What causes this rise ? Molecules always move from a place where they are in larger numbers to places where they are less crowded.

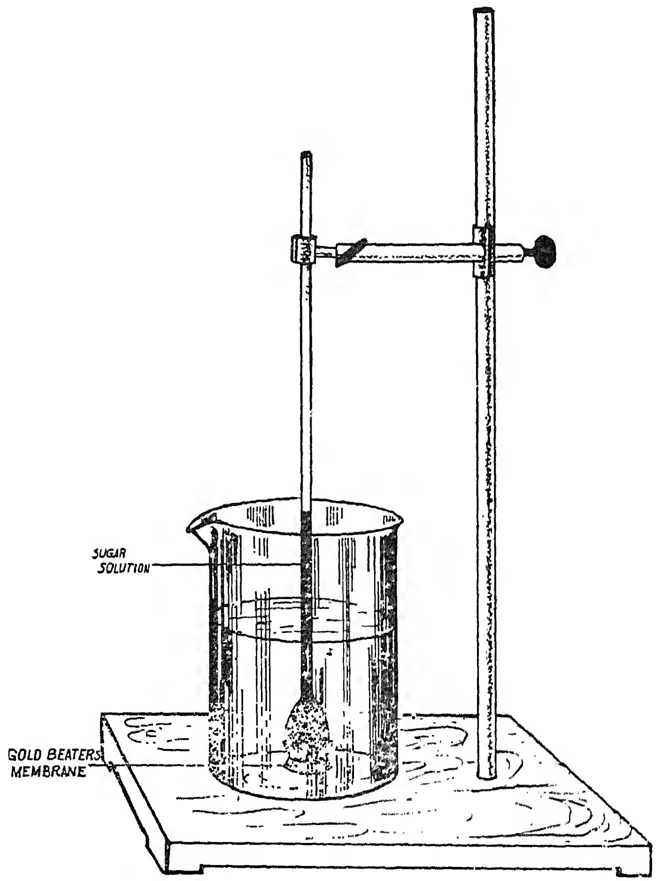


Fig. III.7. Passage of liquid through a membrane.

Major Concept 5. Food is digested and absorbed in the different parts of the digestive system.

Concept 5-a,b (p. 29) : (a) The mouth, foodpipe, stomach, duodenum, small intestine and large intestine form the alimentary canal.

(b) Certain glands are associated with the digestive system which secrete juices to digest various types of food. These are liver, the pancreas, salivary and intestinal glands.

1. Make a life-sized diagram of the body systems. Make cut-outs to scale in different colours of various organs of digestion. The oesophagus might be made out of a piece of rubber tube or plastic hose. Use this model to trace food through the body. Label the parts. Start with the mouth and state the function of each of the parts.

2. Show where the following glands are and state their functions: salivary glands, stomach glands (gastric juice), liver (bile), pancreas (pancreatic juice) and intestinal glands.

3. Make a time-table of digestion such as: at 8 A.M. food is taken into the mouth; by 9 A.M. all the food has reached the stomach and soon the work of the juices and muscles begins. Complete the story. Mention what heppens to unabsorbed and undigested food ?

Concept 5-c,d,e (p. 29) :
(c) Digestion of food mainly takes place in the mouth, stomach and small intestine.
(d) Absorption of food mainly takes place in the intestine.
(e) The undigested and unabsorbed food collects in the large intestine and is periodically expelled.

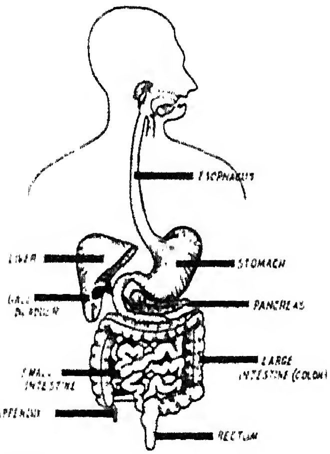


Fig. III.8. Digestive system of man.

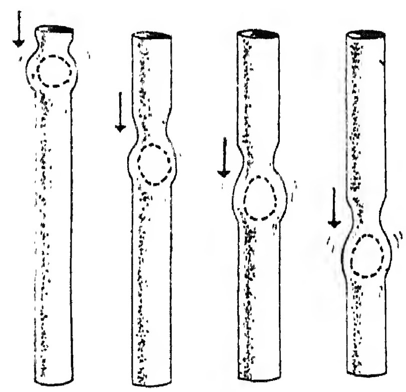


Fig. III.9. Movement of food through digestive system.

Explain how food passes through the digestive system. Place a marble in a rubber tube big enough to move, but not so big as to let the marble roll through. Press behind the marble with your fingers. Watch the marble move. What does the marble represent ? What does the pressure of your fingers represent ?

Major Concept 6. Right habits of eating and getting rid of waste materials are necessary for good health.

Concept 6-a,b,c (p. 29) :
(a) Meal habits should be regular.
(b) Daily diet should be balanced.
(c) Movement of bowels must be regular. If not, the diet needs to be altered by adding some leafy vegetables and fruits to the diet.

Prepare a set of guides on proper food habits, regular habits of eating and elimination of waste.

RESPIRATION AND CIRCULATION

Major Concept 1. The release of energy from food is a fundamental activity of all living things. This is called respiration.

Concept 1-a, b (p. 29, 30): (a) When food within the cells is oxidized, energy is released and carbon dioxide produced.
(b) In this process of respiration every living cell needs a constant supply of oxygen and food.

1. The oxidation of food in the body is sometimes compared to burning. In what ways are these two processes alike ? In what ways are they different ?

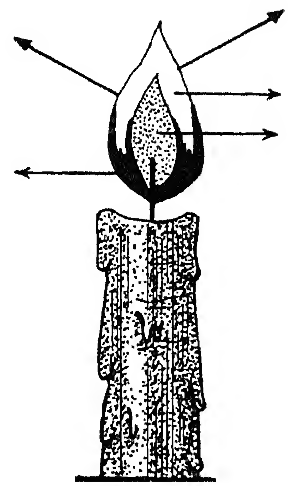


Fig. III.14. Products of combustion.

Invert a clean bottle over a lighted candle. Quickly pour lime water into the bottle and if it turns milky, carbon dioxide is present. As a control, test with lime water, the contents of a clean bottle which has not been inverted over a candle. Moisture inside the inverted bottle shows that water is also liberated during oxidation. So in oxidation, carbon dioxide and water are released, as well as energy in the form of heat. Oxidation can be slow, as in the rusting of iron, or fast as in burning. In the body, oxidation is a slow process.

2. To show that slow oxidation produces heat, measure the temperature beneath a pile of damp grass or hay. Note that this temperature is higher than that of the surrounding air.

Fig. III.15. Heat is released during oxidation.

3. To show in another way that slow oxidation produces heat, take two thermos flasks. In one, place two cupfuls of soaked bean seeds. Seal the top with a cotton plug and insert a thermometer to register the temperature. In the second thermos flask put dry seeds. Seal and insert a thermometer in it also. By watching over several days and observing the changes in temperature, it will be seen that heat energy is produced by the slowly germinating seeds.

If thermos flasks are not available, a suitable insulated container can be made by using a small tin or bottle inside a larger tin with the space between filled with sawdust or other insulating material.

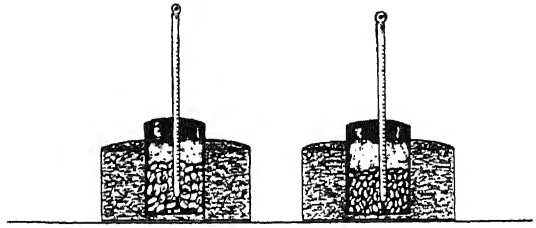


Fig. III.16. Heat is released by germinating seeds.

Major Concept 2. Oxygen is taken to the tissues in many parts of the body, and likewise carbon dioxide and water are carried from the tissues in many parts of the body. This involves the respiratory system and the circulatory system.

Concept 2-a (p. 30) : The respiratory system brings in air to the circulatory system and takes used air from it to expel outside. It is really a ventilating system.

1. How does oxygen get into your body ? Compare the ventilating system of your house with that of the body. Make or draw a model to show how the fresh air gets into your lungs and how used air gets out of the bronchii. Show the nostrils, the larynx, the trachea and the lungs. How does oxygen from the air in the lungs get into the blood, from where it can be transported to other parts of the body ?

2. Learn about the ventilating systems of some other animals. Find out about larval forms of insects, such as mosquito wrigglers. Observe fishes and frogs. Have you observed the bright red gills of fish ? What do these tell you about oxygen getting into the blood stream ?

Concept 2-b (p. 30) : The circulatory system transports food and oxygen to, and waste materials, carbon dioxide and water from the tissues.

(See Concept 5-a.)

Major Concept 3. The respiratory system consists of nostrils, pharynx, trachea, bronchii and lungs.

Concept 3-a (p. 30) : The air is moved in and out of the lungs by the action of the muscles between the ribs and the diaphragm.

1. Devise a way to show how the muscles and ribs assist in getting air in and out of the lungs.

Fasten loosely in a rectangular form thin strips of wood. Now move them from a diagonal

position..........to a straight one. Note the difference in space outlined.

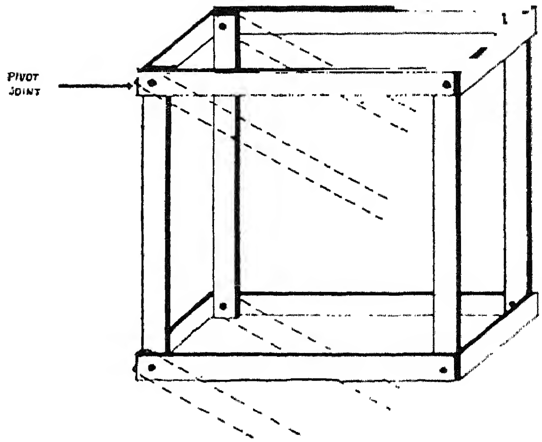


Fig. III.17. Model of mechanics of breathing.

This illustrates how the space in your chest is enlarged when the ribs are raised, causing air to move into the lungs. When the ribs move down, they decrease the chest cavity and air is moved out of the lungs.

2. Draw diagrams to illustrate what happens when you breathe in and breathe out.

3. The diaphragm is a sheet of muscle which separates the chest from the abdomen. Feel your diaphragm. Press hard on it. Try to breathe in.

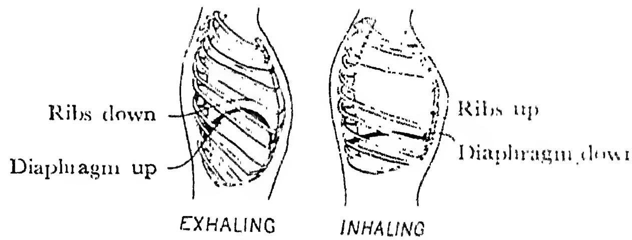


Fig. III.18. Changes in chest cavity during breathing.

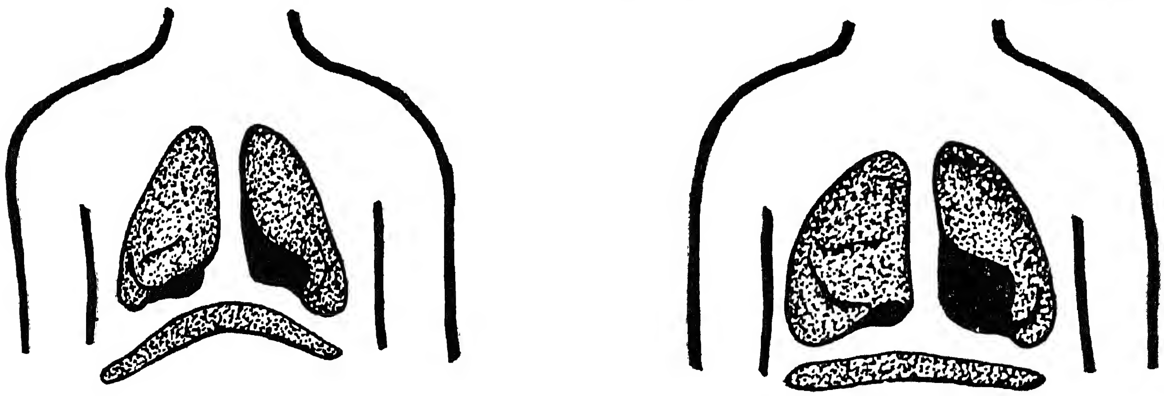


Fig. III.19. Movement of diaphragm in breathing.

Make a model of the lungs to demonstrate the effect of the movement of the diaphragm.

(a) Take a lamp chimney, or a glass jug with the bottom removed. To cut the bottom of a bottle, make a scratch round the bottle, at the required level. Wrap strips of damp blotting paper on either side of this scratch.

Play a fine gas flame on the cut, rotating slowly as the glass begins to crack at this point. Smooth off the raw edge with a file, or by rubbing on a flat ground glass plate on which has been smeared a paste of carborundum powder.

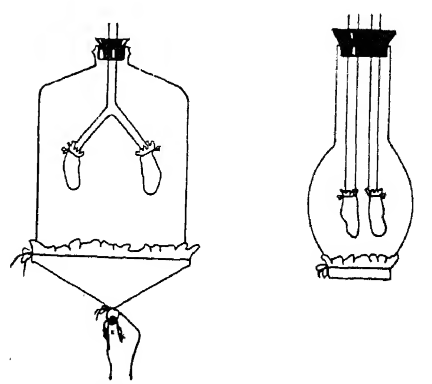


Fig. III.20. Model of the lungs.

(b) Device for cutting glass jars.

It is often necessary to cut the top or bottom of jars or bottles to make them usable for classroom purposes, such as terraria or respiration apparatus. The piece of apparatus in Fig. III.21 will prove very useful for cutting such glassware cleanly. Be sure to wrap the nichrome wire firmly about the jar or bottle to be cut and cross the handles to hold the wire in this position. After the cutting process, it is necessary to smooth the sharp edges with a file or wire screening.

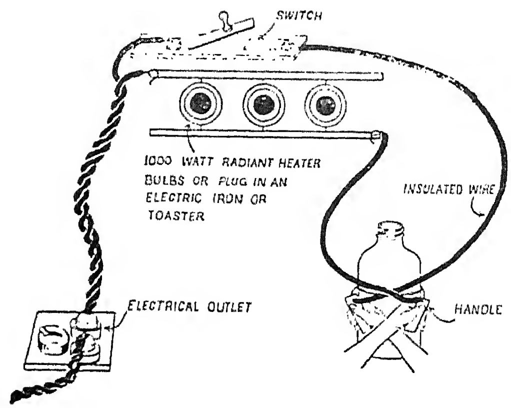


Fig. III.21. Device to use in cutting glass jars.

Use a glass jug cut as above or a plastic container. Secure over the open bottom a piece of balloon, half of a football bladder retaining the stem end or a piece of an old inner tube. Tie off a bit of rubber at the bottom to provide a handle for operating.

If a Y-tube is not available on which to hang two balloons (the lungs), use either a two-holed stopper and two tubes or a single tube. Can you plan another way to set up this apparatus ? The local tinker may be asked to make a Y-tube from a tin piece and solder it.

Now pull down on the rubber bottom (the diaphragm). Observe what happens to the balloons (the lungs) in the jar. Relate this to the way your diaphragm works.

Concept 3-c (p. 30) : The warm air passes through the wind-pipe and is distributed to the two lungs through the bronchii and bronchial tubes.

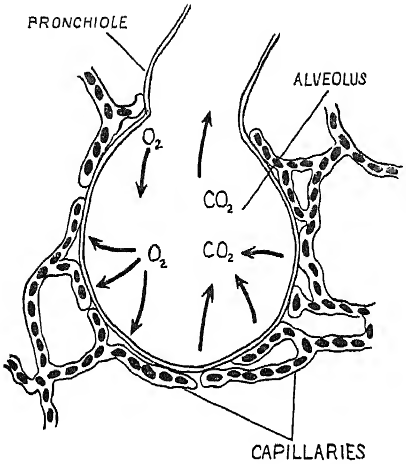
Discuss in class why it is better to breathe through the nose than the mouth. Bring out the warming and cleaning functions of the nose. Under what conditions do people become 'mouth breathers' ?

Concept 3-d,e (p. 30) : (d) The lungs consist of millions of tiny air sacs in which the final branches of the bronchial tubes end.

(e) The walls of the bronchial sacs are covered with a network of capillaries through whose thin walls oxygen diffuses from air sacs to blood capillaries, and carbon dioxide and water vapour pass out from capillaries to air sacs of lungs.

It has been said that if all the air sacs in a normal adult's lungs were laid out side by side, they would cover a football field. Does this give you an idea of the vast surface available for exchange of gases in respiration ?

In your model of the lungs, show the bronchii separating into finer and finer tubes until you show the detail of the millions of air sacs whose walls are only a cell or two thick. Be sure to show the network of tiny thin-walled capillaries around the air sacs. Oxygen from the air dissolves in the moisture of the air sac and passes through the alveoli into the capillaries.



Review your study of diffusion or set up a demonstration to remind you of how food and oxygen can pass through membranes.

In a like manner, carbon dioxide passes from the blood to the air sacs. (See demonstration of concept 5-a.)

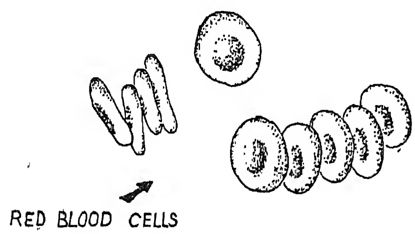
Fig. III.22. Shows bronchiole ending in alveolus.

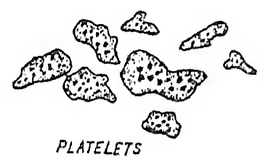
Concept 3-f (p. 30): The haemoglobin in red blood cells has the capacity to absorb large quantities of oxygen. This oxygen is carried to the tissues by the blood stream.

A red protein compound called haemoglobin, containing iron and other elements enables the red blood cells to carry oxygen from the lungs to the cells of the body, and carry carbon dioxide from the cells to the lungs. Observe that when an iron nail is left out in moist air it will turn red with rust. Iron combines easily with oxygen in the air.

Haemoglobin with its iron content has the capacity to carry quantities of oxygen to the cells.

Read some more about the blood. Find out about the red blood cells; you will find that these are so small that 10 million of them could be placed on a 5 sq. cm. area. Draw a square 5 cm. side to help you visualize this. Under a microscope white blood cells or leucocytes and platelets much smaller than red blood cells can be observed.





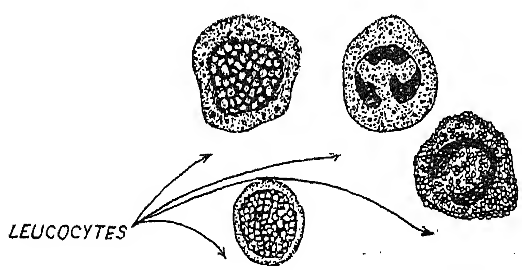


Fig. III.23. Blood components.

Get a fresh bone from a butcher. Get it sawed through. Now look at the red part, called the red marrow. Here is where red cells are formed.

Concept 3-g (p. 30) :	The oxygen from the haemoglobin diffuses through the capillary walls to the cells of the tissues.

1. Study the illustration given and see if you can explain it. Better yet, illustrate your own ideas.

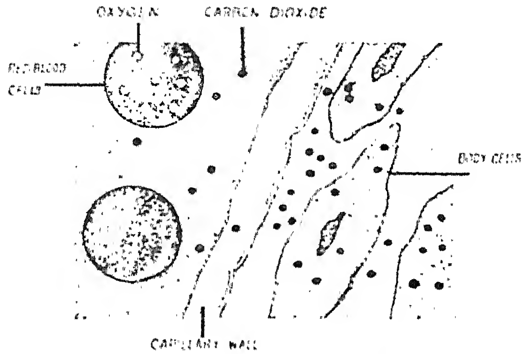


Fig. III.24. Exchange of gases between blood and cells through capillary wall.

2. Start with an imaginary molecule of oxygen in the air just outside the nostrils. Now take a breath and follow this oxygen around your body until it becomes a part of the cell. How did it go through the cell wall ? Look at Fig. III.24 and see if you can explain what is happening.

Some have referred to the blood as a transportation system. What will it get from the cell to transport away ? Breathe against a mirror. Do you notice the moisture present ?

Food as well as oxygen moves from the blood into the tissues ; carbon dioxide; water and wastes move out of the tissues into blood.

Concept 3-h (p. 30) :	Carbon dioxide and water diffuse out from cells into the capillaries. When the blood reaches the lungs, the waste gases diffuse out from the capillaries of the air sacs into the lungs.

Do you breathe out carbon dioxide ? Many of you have tried the test for carbon dioxide, but some have not done this. Since there is a small percentage of carbon dioxide in the air at all times, it will be well to demonstrate the carbon dioxide content of exhaled air by a test like this :

Connect a glass Y-tube to two sections of rubber tubing. Then fit one short and one long glass tube into each of two 2-holed rubber stoppers which fit the two bottles or flasks. Attach the rubber tubing to the short section of the glass tubing in flask B and the longer sections in flask A. Fill flasks about one-third full of lime water. Put a straw at the end of the tube so that it could be changed for each person. Inhale and exhale without taking the lips from the straw. As you inhale, does lime water change in flask B ? Note the change in the lime water in flask A. As you inhaled you removed air from flask B and more outside air entered the flask and bubbled through the lime water Still there was no change in the lime water. What conclusions can you draw ?

If a Y-tube is not available, arrange to inhale air from a tube connected to flask B as in Fig. III.25 and to exhale air into another tube connected to flask A.

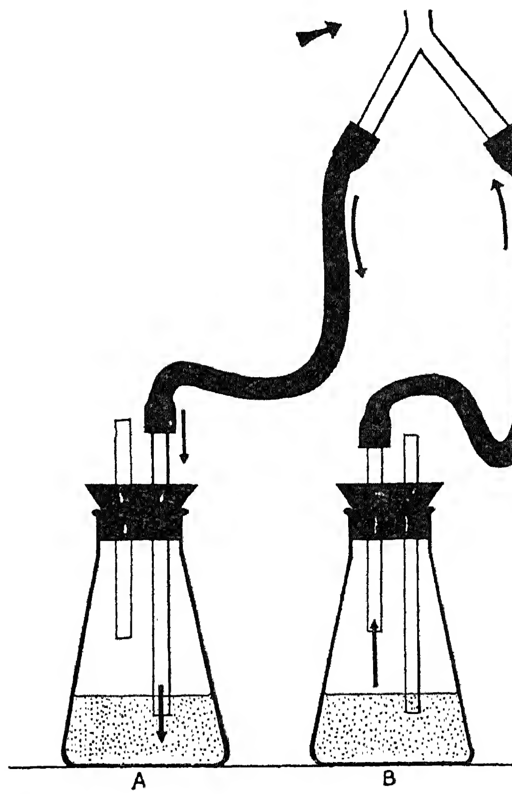


Fig. III.25. Comparison of exhaled and inhaled air.

Major Concept 4. The circulatory system consists of the heart, arteries, veins, capillaries and blood.

Concept 4-a (p. 31): The heart is an involuntary muscular organ. It ceaselessly pumps blood to all parts of the body.

1. To study the structure of the heart, obtain one from a butcher's shop. Find the pulmonary arteries and the pulmonary veins. Through which cut blood vessel can you push a pencil? Compare the thickness of the walls of the arteries and the veins. Cut open the side of the aorta and find the valves. Cut the heart from top to bottom to show the partition down the middle. Find the two pumping stations. Observe the upper part or auricle and the lower part or ventricle of each side. Notice the thickness of the walls. Trace the passage of blood through the heart, past various openings. Locate the valves.

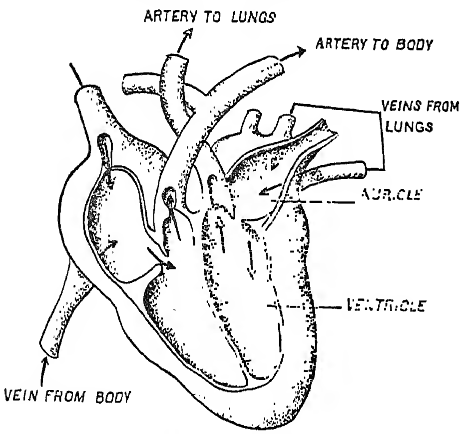


Fig. III.26. Model of heart.

2. Make a home-made stethoscope and listen to the heart beat. Take a small funnel. Attach to it a plastic or rubber tube with a Y or T (perhaps a tinker can put a Y on your funnel), so that

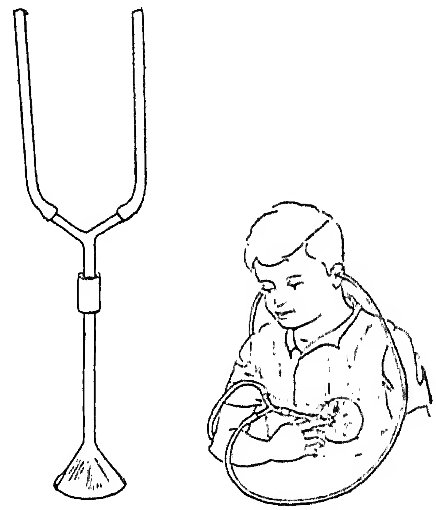


Fig. III.27. Improvised stethoscope.

you can attach two tubes. Possibly you can make a Y from plastic tubing sealing it to your funnel with a suitable cement. Place the funnel end over your heart and put the tube ends in your ears. You will hear the heart beat. This activity will generate many questions about the heart and health. What sounds do you hear? Are they regular or irregular? If you loan your stethoscope, be sure to wash the tube ends with spirit each time, so that no transfer of germs will occur.

Concept 4-b (p. 31): Arteries carry blood from the heart to the rest of the body. Their walls are muscular and they contract along with the heart.

Try finding the beat of blood vessels as blood moves through an artery. Place two fingers on the thumb side of the inner wrist while pressing on the back of the wrist with the thumb. Why should you not feel the pulse with the thumb? (A pulse beats in your thumb.) What do you feel? Try two fingers on the front of your throat and feel. Also try the side of your head. Where else can you feel your pulse? Try your ankle. Count your pulse for a minute. You are counting the number of times your heart beats. Make a graph of the pulse-rates of your classmates. Would you like to 'see' your

pulse? Stick a drawing pin or thumb tack in the end of a match. Hold your inner wrist flat and

Fig. III.28. Demonstration of pulse movement.

place the head of the tack on your wrist where you felt your pulse. Now watch the movement each time your heart beats. Can you also feel a pulse in your veins?

Some of you may wish to find out more about your heart. Suppose your heart beats 80 times a minute. How many times will it beat in a day? in a year? Of course, your heart beat much faster when you were a baby than now and it was also beating before you were born. By doing a little arithmetic, you may appreciate what a wonderful organ the heart is. Take and record the pulse rate and age of many people of different ages. Prepare a chart showing your results.

Concept 4-c p. 31 : The arteries finally branch into fine capillaries which run through the tissues of various organs.

Observe blood flowing through capillaries. For this you will need a microscope, a wooden board with hole at one end, a cloth bag, a few small nails and a small fish. Wrap the fish in the wet cloth bag with just the tail fin protruding and placed above the hole in the board. Nail the bag in place to the board and examine the fin under the microscope. The tiny moving circles you see are red blood cells. The tubes are capillaries. Be sure the fish is kept wet. Do not keep it long under the microscope.

With careful handling the fish will not be injured. It is best to wet the cloth with the water in which fish was originally living. You can distinguish the arteries by the stop and go movement, while the blood flows smoothly through the veins.

The web of a frog's foot may also be used to study circulation.

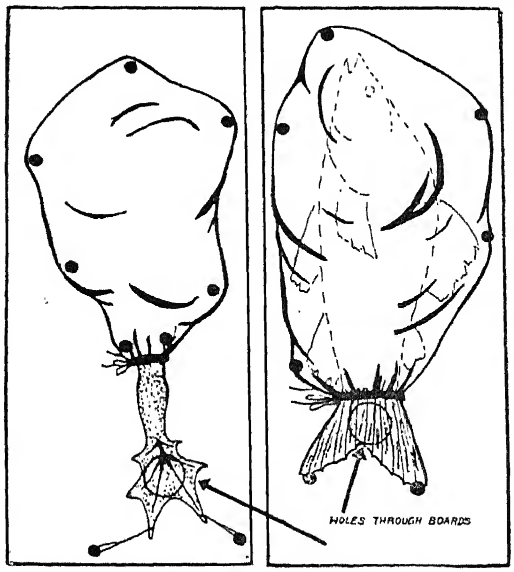


Fig. III.29. Observing blood circulation.

Concept 4-d, e, f. (p. 31) : (d) These capillaries unite to form veins which carry blood back from the organs to the heart. Veins have valves which prevent back flow of blood.

(e) The pulmonary artery takes blood from the heart to the lungs to oxygenate it.

(f) The pulmonary veins take the oxygenated blood from the lungs to the heart for circulation in the body.

1. Locate the valves in your veins. With your arm hanging down put your finger against a vein on your forearm or at the back of your hand. With another finger squeeze the blood out of the vein by rubbing it along the vein towards the heart. Notice how the vein seems to disappear.

You have pressed the blood out of it. Now take your finger away and watch the vein fill up. Which way did it fill up ? (From finger to back of hand.) Why ? The veins have valves that prevent the blood from flowing backwards away from the heart. The valves allow the blood to flow only towards the heart. You can get an animal vein from the butcher and test the vein in flowing water, first at one end and then at the other. Can you guess which way the valve is pointing inside ? Study the vein closely, cutting it open after testing as above.

2. Refer to development under concept I-4a on work of pulmonary veins and arteries.

Concept 4-g (p. 31): The circulatory system is a closed system of pipes containing blood.

Why does blood flow out of the body ? Demonstrate that the blood flows in a closed system in the body.

1. Take a rubber syringe to which are attached at each end a large sized plastic or rubber tube. Connect these large tubes by tubes of smaller diameter to represent capillaries. Now fill the syringe with coloured water and watch the 'blood' flow from arteries to the capillaries, to the veins and back to the heart. By attaching a flat piece of wood such as a short measuring stick to the artery end, the pulse can be demonstrated as the syringe is worked. To make 'blood' flow in one direction, apply pressure at vein end of apparatus, releasing at proper time.

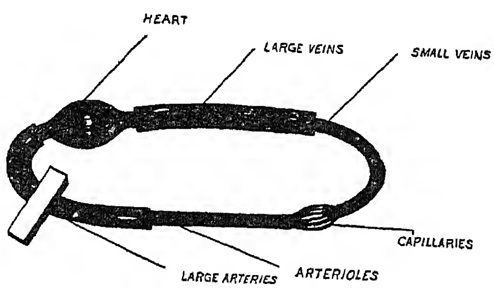


Fig. III.30. Model to demonstrate pulse movement in closed circulatory system.

2. Make a model of the respiratory and circulatory system with chicken wire covered by papier mâché. Use plastic tube, filled with coloured liquid or red and purple yarn for blood vessels. Use heavy yarn near the heart and finer yarn farther from the heart. Tiny threads can represent capillaries. Label parts to show how food and oxygen are transported to the tissues while carbon dioxide, waste products and water are transported from the tissues.

3. Make a flannel board model of the respiratory and circulatory systems. Show that the parts responsible for getting the material to and from the cells represent a closed system, lungs to heart, to body and back, *via* arteries and veins. Students need a number of concrete illustrations to develop the idea that the food they eat and also the air they breathe make cells grow, and that this is a continuous process.

Major Concept 5. The blood has many functions.

Concept 5-a (p. 31): Blood transports oxygen, food and carbon dioxide and other waste materials to and from appropriate organs and tissues of the body.

How do oxygen and food get into the cells and how are wastes removed? Review your experiments on diffusion. Tie a piece of cellophane or a membrane from a meat market over the open-end of a bottle or end of a thistle funnel after putting into the bottle or bulb of the thistle funnel some molasses or sugar solution. Invert the bottle or thistle bulb in clear water. Observe the movement of the liquid through the membrane. In which direction does it move faster? (From the place of greater concentration to that of less concentration).

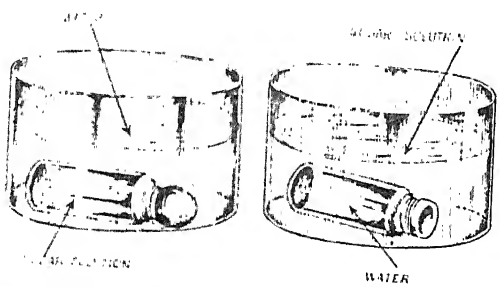


Fig. III.31. Movement of material in and out of model cell.

When you do this, wrap the string tightly several times around the membrane you place over the top of the bottle to prevent leakage. From the bulging of the membrane we infer that something passes through the membrane, faster in one direction than in the other, increasing or decreasing the internal pressure. In a living cell increased pressure results in a turgid, or swollen condition, whereas reduced pressure results in a flabby condition. Clearly, materials pass in and out of the model cells.

In much the same way materials pass back and forth through very thin cell membranes.

Concept 5-b (p. 31): Blood regulates temperature.

To become convinced that the blood distributes heat energy from one part of the body to another, hold an ice pack on the back of your neck for a short while and notice how you feel chilly all over your body.

Another way to show this, is to soak both feet and ankles in hot water and find that you soon begin to perspire.

Concept 5-c (p. 31): Blood fights microbes entering the blood stream.

Have you heard of people having blood counts taken when they are ill? Do you know what is counted? In your blood there are both white and red cells. To every 5000 red cells there are about 7 white cells. The white cells ward off harmful bacteria and viruses. White cells reproduce fast and travel freely in the lymph system. How would a count of white and red cells read if a person had an infection? (The count of white cells would be very high if you were ill). Poisons produced by harmful bacteria and viruses activate the white blood cells. White cells can digest bacteria and thus destroy them.

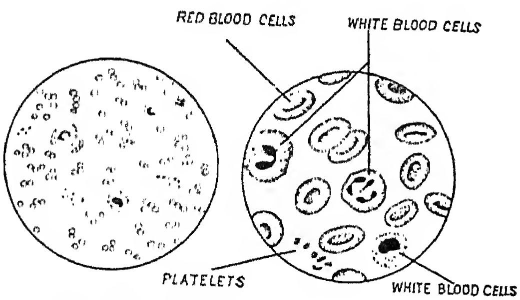


Fig. III.32. Cells and platelets in blood.

Have a talk with a doctor or nurse about taking blood counts as used in detecting illness.

Concept 5-d (p. 31): Blood prepares antitoxins to neutralize poisons formed in certain diseases.

Find out how a particular antibody formed in the blood 'fights' disease. Have you been vaccinated for small-pox or inoculated against cholera, diphtheria, yellow fever or typhoid fever? In some cases small amounts of the disease germ are injected so that the person will develop anti-bodies to fight that particular disease. This will be developed in Class VIII, Control of Disease, Concepts 1—4.

Find out if there are any diseases prevalent in your community. What is being done to stop these diseases?

Concept 5-e (p. 31): Blood forms clots in minor cuts and injuries preventing further loss of blood.

Why do not people bleed to death when they get a cut? Next time you are cut, try to get a magnifying glass to look at the blood near the cut. Does it look like a network of tiny threads? A substance in the blood plasma, called fibrinogen, when exposed to air, hardens. We say the blood clots. What happens when the cut is large and deep and the blood flows fast?

Major Concept 6. Breathing and circulation of blood are interrelated, involuntary and continuous processes.

Concept 6-a (p. 31): Breathing cannot be stopped consciously for more than a few moments.

Hold your breath for a short while. Why is it that you cannot hold it very long? Do you have to tell yourself when to breathe? No, your body regulates this process automatically.

Concept 6-b (p. 31): The pulse beats constantly indicating the contraction and expansion of the heart.

(See Concepts 4-b and 4-g.)

Major Concept 7. When a man loses a lot of blood he needs a blood transfusion to save his life.

Concept 7-a (p. 32): There are four types of blood.

The four blood groups are classified on the presence or absence of the two agglutinins (clotting agents), A and B, found in red blood cells. Both these proteins are found in AB type of blood and both are absent in O type blood. When type A is added to type B it clumps, (clots) and *vice-versa.*

TABLE III-8 BLOOD TYPES

If cells contain	Group is called	Serum will contain	Patient can be transfused with	Patient cannot be transfused with
A antigen	A	anti-B antibodies	A, O	B, AB
B antigen	B	anti-A antibodies	B, O	A, AB
A and B antigens	AB	no antibodies	AB, A, B, O	————
Neither A nor B antigens	O	both anti-A and anti-b antibodies	O	A, B, AB

Roughly 45% of the population have type O; and 42% have type A. Do you know your blood type?

Concept 7-b,c (p. 32) : (b) For a blood transfusion a patient needs a compatible type of blood.
(c) Different types of blood are donated by different individuals.

In blood transfusions, the blood of the giver must be typed and matched with that of the patient. The matching is done by adding a drop of the patient's blood to that of the giver. If the red blood cells clump together, they are incompatible (not suited to each other).

Typing is not necessary when blood supply is needed in volume. Then the plasma without red cells is given.

Concept 7-d,e (p. 32) : (d) Only healthy people, after medical examination, can donate blood, once in three months.
(e) A healthy man can donate half a litre of blood at a time.

Discuss how much a half litre is. This is the quantity of blood which a healthy man or woman can donate once every three months. Why should only healthy individuals donate blood ? Discuss.

Concept 7-f (p. 32) : The donated blood stored in hospitals is called a blood bank.

Request a local doctor to explain the Blood Bank to you. (Refer to the pamphlet '*Blood—The Life Saver*', N.C.E.R.T., 114-Sundar Nagar, New Delhi-11.)

You will be interested to know that whole blood can be kept in a vacuum flask (why?) under refrigeration (why?) at 5° C for as long as a month. Each bottle contains a litre mixed with a chemical and dextrose to prevent clotting.

Excretion

Major Concept 1. All living cells produce waste materials which are excreted through various organs, namely, lungs, kidneys, and the skin.

Concept 1-a,b,c,d(p. 32) : (a) Carbon dioxide and water are formed when food is oxidized in the body cells.
(b) Proteins break up into various compounds containing nitrogen.
(c) Accumulation of waste products is harmful to the body.
(d) Blood circulation takes all waste products to respective excretory organs.

Draw a model of the body and place thereon the organs of excretion as studied. Try to

determine how they are related. Show how the blood is the transporting medium for carrying all wastes of the body to the excretory organs. Draw figures about your ideas.

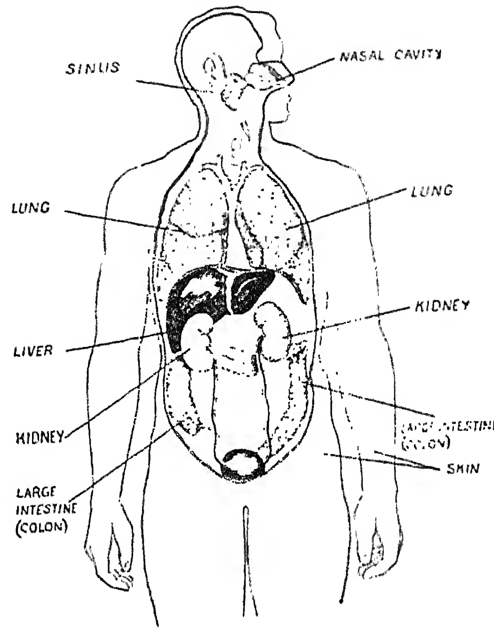


Fig. III.33. Some excretory organs of the body.

Major Concept 2. The lungs remove waste products—carbon dioxide and water vapour.

Concept 2-a,b (p. 32): (a) The blood from all over the body enters the lungs through the heart.
(b) Carbon dioxide and water vapour are expelled with air breathed out.

Review circulation using models made earlier.

1. You have already seen how it can be shown that carbon dioxide is excreted as a waste during respiration. (See class VII, 3-h).

2. To show that water also is excreted by the lungs during exhalation, have students breathe against a blackboard or a mirror.

Major Concept 3. The kidneys remove nitrogenous waste and salts from the blood.

Concept 3-a,b,c,d (p. 32-33): (a) The kidneys contain thousands of tiny tubules which have a network of blood capillaries.
(b) The nitrogenous waste, salts and water are removed from these capillaries and they form a mixture called urine.
(c) The tubes of the kidneys join into larger and larger tubes and finally into one large tube from each kidney to lead to the urinary bladder.
(d) Urine collects in the urinary bladder and is periodically expelled when the bladder is nearly full.

The kidneys act as filters. How does a filter work? A filter is a device for separating by

straining one substance from another. Get an untrimmed kidney of sheep, goat, or frog. Study the fat capsule which envelops the kidney. Remove this sheath and slice the kidney lengthwise. Observe the region rich in tubules and capillaries. If all the tubules in a human kidney were straightened out and laid end to end they would cover 200 miles. These small tubes join into larger tubes. Large tubes, called ureters empty into the urinary bladder.

Make a drawing or a clay model of the human kidney labelling the parts and explaining the function of each part.

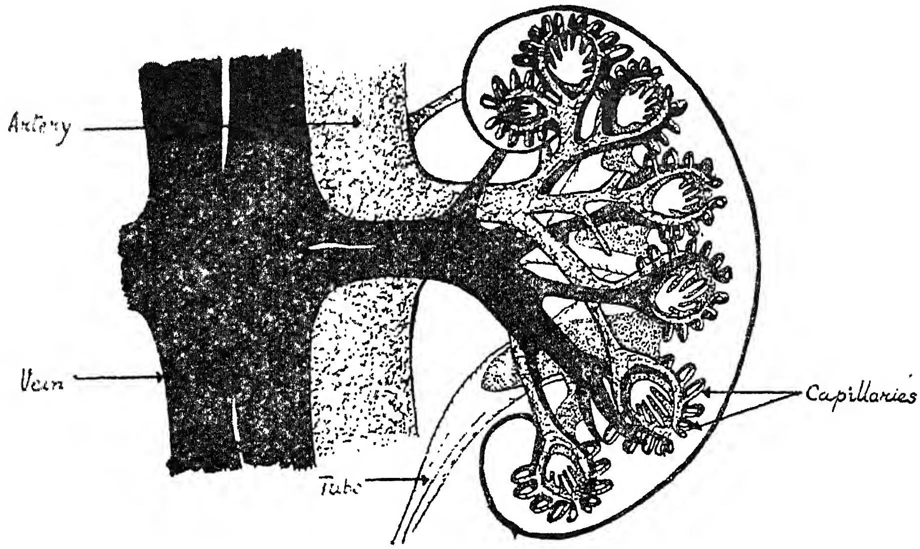


Fig. III.34. Cross section of a kidney.

Major Concept 4. The skin consists of two layers that perform different functions.

Concept 4-a,b,c,d,e (p. 33) :
(a) The upper layer is called epidermis which is a protective layer of horny cells.
(b) Beneath the epidermis is the inner layer called dermis which contains pigment cells, nerve endings, sweat glands, oil glands and hair roots.
(c) The sweat glands work like the kidney tubules and expel nitrogenous waste, salt and water as perspiration (sweat).
(d) The oil glands exude oil in tiny quantities to keep the skin smooth.
(e) The pigment cells give the characteristic colour to the skin.

Models of the skin are available in the market but some schools may not have them. Models can be made of clay, using different colours for the layers, the nerve endings, the sweat glands, oil glands, hair roots, and pigment cells.

Use a hand lens to look carefully at the skin or different parts of the body. You are looking at the outer layer or epidermis.

Draw a cross section of the skin on the blackboard using various colours for the parts. From an opening (a pore) on the surface draw a long shaft ending in a coiled tube, the sweat gland. What kind of blood vessel encircles the cells? Enmesh this sweat gland with capillaries. In this way draw a picture of the skin and name parts.

Use a film to review the uses of the various organs in excretion. Use books besides the text to extend reading and bring in more illustrations of the content material.

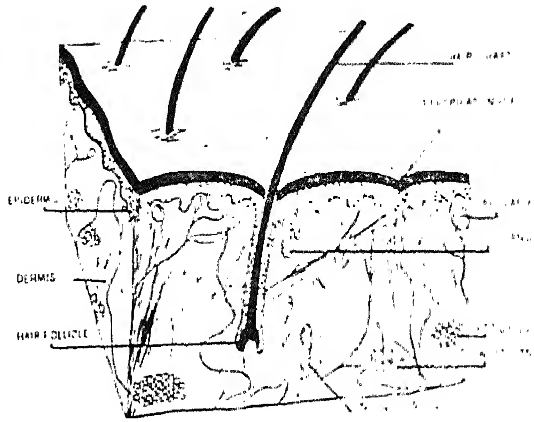


Fig. III.35. Cross section of the skin.

Concept 4-f (p. 33): The nerve endings give the sensation of touch, heat and cold, pressure and pain.

Devise means for testing the sense of touch, heat and cold, pressure and pain.

1. Have a student keep his eyes closed during the experiment. Take a cork with 2 pin-points or a pair of calipers. Gently prick the skin and have the student say how many pricks occurred. If the points are far apart, the person feels two pricks, if close, only one. Do an experiment to discover where the nerve cells are closer, on the the forearm or at the finger tips. Find nerve cell endings for heat and cold by using a hot glass rod (not too hot) and a very cold rod. Mark nerve cell endings with red ink.

2. Take 2 pans of water, one at 40° C and the other at 20°C. Put a finger from each hand in each pan at the same time. After 30 seconds, put both fingers in a pan at 30°C. How do they feel? Vary this experiment with colder and warmer water, using the 30°C in between trials.

Concept 4-g (p. 33): The evaporation of sweat on the skin cools the body.

To show the cooling effect of evaporation of sweat, wet some cotton with alcohol. Quickly apply it to one hand of several pupils in the class. Why does the hand wet with alcohol feel colder? When the liquid evaporates, it takes heat from the surface of the skin, and the skin feels cool. Using this as a guide, explain in your own words how sweating is a cooling process.

Concept 4-h (p. 33): A daily bath is essential to remove waste material deposited by evaporation or sweat.

From what you know of the organs that remove waste from the body—skin, kidneys, and lungs—frame a set of health rules to apply to your daily life.

NERVOUS SYSTEM

Major Concept 1. The nervous system is made up of nerve cells.

Concept 1-a, b (p. 33) : (a) Typical nerve cell has three parts:
1. The cell body.
2. The dendrites
3. The axon

(b) Nerve cells are found principally in the brain, the spinal cord and ganglia.

Your nervous system is composed of billions of nerve cells. To show its structure, construct a model of a nerve cell with plasticine or illustrate it in colours to distinguish the various parts. This will be a very rough model because any cell —and there are a number of kinds of cells—is an extremely intricate and complicated unit of the body. You may wish to draw several kinds of cells, thus showing how the nerve cell differs from these. They differ in shape and in function. You will see the parts in the illustration. Not all nerve cells are of the same size; some may have axons several feet long while others may be very short. But all do the job of carrying messages to and from the brain, spinal cord and ganglia.

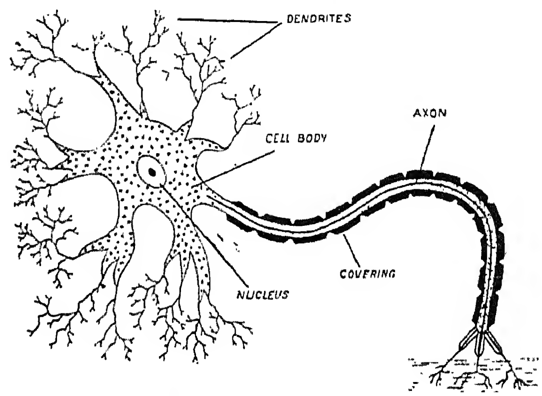


Fig. III.36. Nerve cell.

Major Concept 2. The nervous system co-ordinates the activities and functions of the body. It consists of three systems, the central nervous system, the peripheral nervous system and the autonomic nervous system. The brain and spinal cord house the neural centres of both.

Concept 2-a (p. 33): The central nervous system largely controls voluntary, conscious activities. It enables an organism to respond to stimuli from the environment.

1. Ask someone to eat a piece of candy while writing a sentence on the blackboard which you read to him. Now ask everyone else to write down all the activities being carried on by the person at the board. Will the list include: he is breathing; his heart is beating; his eyelids are closing every few seconds; the muscles of his digestive track are churning the food of his last meal? You think nothing of these things. How is it that a nervous system can handle these activities, plus the walking, hearing, smelling, writing, chewing, thinking?

Which activities can you control? Which are those you are unable to control? Which do you always have to think about? Which do you sometimes think about? Which do you never think about?

2. Obtain a portion of an animal backbone from a meet market. A chicken backbone will do. Some may contain a portion of the spinal cord and nerves. Observe the hole through which the spinal cord passes. Think of the many nerve cells in the spinal cord each of which has a connection with the brain. In Fig. III.37 note the connections of the sensory branches of the side

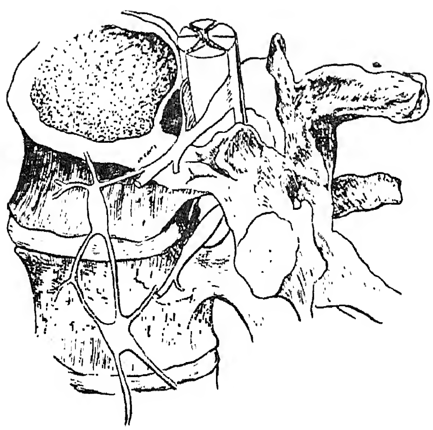


Fig. III.37. The main nerve axis in vertebrates.

nerves to the back of the spinal cord and of the motor branches to the front of the cord. Also note the conn ections of the autonomic ganglia to the spinal cord in Fig. III.38. Consider the many muscles all over your body that get messages to tell them what to do. Have you ever seen a telephone switch-board? How does it keep the messages straight? Think what your spinal cord and brain do.

3. Have someone show an electric question board or describe it by illustrating the wiring on the blackboard. Show that, with such electrical connections, each stimulus is associated with a particular response. In this way an appreciation of the complex nerve connections that exist in the brain and spinal cord can be developed.

4. Use wire netting and papier mache to construct a model of the brain showing the different parts: cerebrum, cerebellum, and medulla. Be sure to show the connection with the spinal cord.

5. Make a model with a stiff dough made of two parts flour and one part salt mixed with enough water. This will be pliable for a long time, yet will eventually dry into a hard model and can be painted. Before it dries, stick in heavy string to show important nerves.

Concept 2-c (p. 34): Both systems are highly interdependent; they function in a unified way.

Recall those activities you listed over which you had no control such as heart beat, breathing, digestion, work of various glands. Clumps of nerve cells called ganglia control these.

These form part of the autonomic nervous system. Look up the meaning of the word *autonomic*. Do you think this system is well-named? These ganglia of the autonomic nervous system are located outside the central system, one chain on either side of the spinal column. They are connected by branch nerves with the central system, and some are found close to the organs they control. How do you think the autonomic system is kept busy?

Even though the two systems are independent, they work together for the benefit of your body. Suppose someone opens a door and you feel cold. You may shiver or get goose pimples on your arms and legs. This is your autonomic system operating. At the same time your central nervous system is working to tell you to either shut the door or put on a coat. Your senses are helping you see, feel, hear, taste and touch.

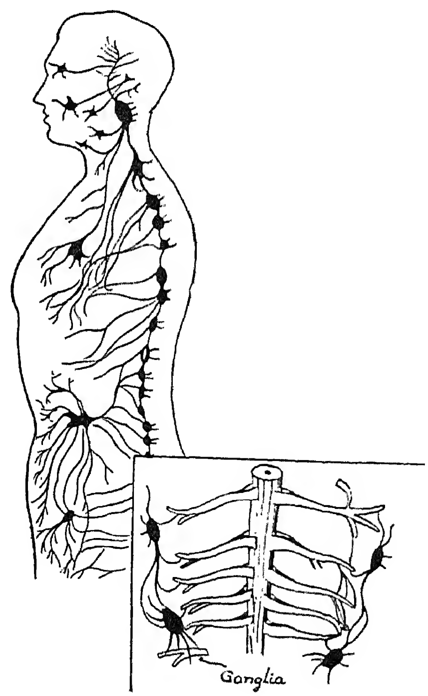


Fig. III.38. Ganglia of autonomic nervous system.

Major Concept 3. The central nervous system receives stimuli from the various sense organs and enables muscles and glands to respond.

Concept 3-a,b,c (p. 34): (a) The sense organs (skin, nose, ear, eye and tongue) receive the stimuli from the environment.
(b) Some nerves carry messages from the sense organs to the brain.
(c) The message must reach the brain before we feel the touch, taste, smell, hear or see.

1. How do your senses help you to know your environment? Rub your hand over your desk. How does it feel? Rough, smooth, dirty, sticky, cold, hot? How do you know how the page feels? Nerves in your skin relay the message. Move the pencil point to touch one hair of your arm. Now move the point over many hairs without touching your skin. When a hair is bent, the position of the hair base changes slightly and this stimulates a sensory nerve fibre. The resulting nerve impulse is relayed to the brain and the resulting sensation is called *touch.*

2. Sort out your senses and decide which one you can best live without. Give reasons for your answer. Which, if any, can you live without—the eyes, the ears, the skin, the nose or the tongue?

Concept 3-d,e (p. 34): (d) Reactions to stimuli are transmitted from the central nervous system by nerves to the glands and muscles.
(e) The glands and muscles of the body respond to these stimuli.

1. Show some delicious sweets to the class. Discuss the taste and enjoyment one gets from eating sweets. Compare these sweets with others. Ask if they would care to eat some. Then check to see if their mouth is 'watering' (saliva flowing—gland action), feel hunger (muscles contracting.)

2. Recall a situation when your anger flared, which anger is caused by a secretion of the adrenal gland stimulated by the nervous system.

Major Concept 4. Responses to external stimuli may be voluntary or involuntary, inherent or learnt.

Concept 4-a,b (p. 34): (a) Some responses are voluntary or willed by the individual.
(b) A reflex action is an involuntary inherent response to a stimulus.

Remember, when you touched a hot dish or stove? Explain what you did. Then look at the illustration (p. 90) to explain how the message went from a sensory nerve cell or neuron to your spinal cord where a connection was made to a motor neuron which sent an impulse to your arm muscle to pull your hand away from the hot pan. All this happened fast. Some scientists think the impulse or message is like an electric current. Your body has some built-in actions which you did not have to *learn* called *reflexes.* Try these, working with a partner. Discuss your findings about reflexes.

1. In demonstrating the knee jerk, one of the pair sits with crossed legs so that one leg is swinging freely. The other partner strikes just below the knee cap with the edge of his hand. Observe the free leg.

2. With a hair or thread tickle the inside of nostrils.

3. Draw the thumb nail briskly forward along the bottom of a bare foot of your friend.

4. Pass a card near the eyes of a student and observe the blinking reflex. Count the number of blinks per minute for a subject in a relaxed position.

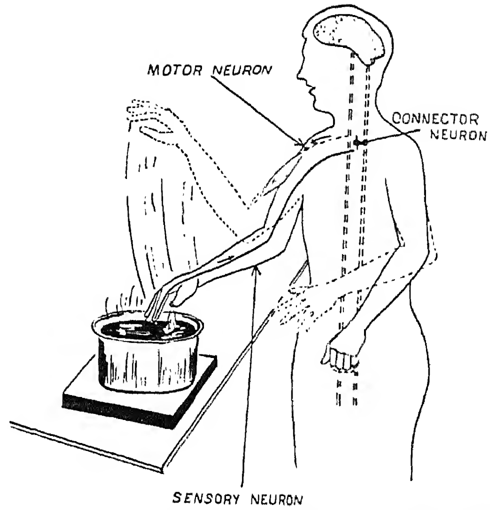


Fig. III.39. Reflex action.

Concept 4-c (p. 34): Habits are learnt responses that have become involuntary.

Are you a slave to your habits?

Demonstrate habit formation. Write your name as many times as you can in a minute. Now switch hands and try the same thing. You can learn a new habit by trying to write your name five times each day with the unaccustomed hand. Do this for a week. Have you improved?

Make a list of five desirable habits which you wish to form. Discuss how habits are formed. Each one should make a plan to establish such habits. It would provide group interest to check regularly to see how the habit formation is progressing.

Can a habit be changed?

Take a firmly established habit like writing the number 6 beginning at the top. Provide practice for writing 6's beginning at the bottom loop, by dictating a series of three digit numbers, each containing one or more 6's. As soon as the new habit is well established, let everyone choose which habits to keep. This may provide a pattern for removing bad habits.

Major Concept 5. The sense of touch is located in the skin all over the body in a very large number of receptors.

Concept 5-a, b (p. 34): (a) The skin has five kinds of receptors (nerve endings) each sensitive to one type of sensation:

1. Pressure
2. Warmth
3. Cold
4. Touch
5. Pain

(b) Nerve fibres carry stimuli from these receptors to the brain and the spinal cord.

The nerve endings in the skin are terminal branches of dendrites or receptors. To demonstrate different receptors (nerve endings) in the skin, keep eyes closed and press a sharp pencil point in a number of places on the end of the index finger. State the sensations felt. Were any of heat? Cold? Pain or pressure? Did you have to press harder to get sensation of pressure? This will help with the understanding of sensory nerves. How do you feel heat or cold?

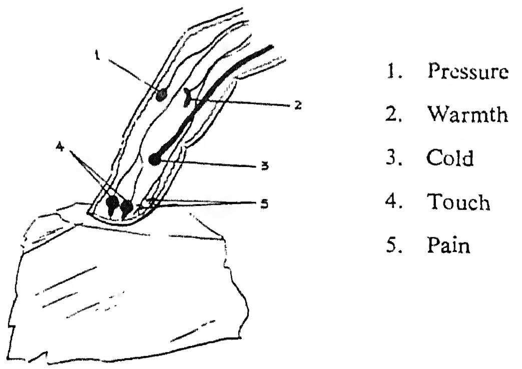


Fig. III.40. Sensory Receptors.

Nerve fibres carry the stimulus from these receptors to the brain and spinal cord. Each receptor is suited to carry one type of stimulus.

Nerve endings of touch may be clustered together very densely as on finger tips, palm, and lips, or very sparsely as on the back. Can you devise an experiment to show this?

Sometimes, sensations are difficult to analyse. Put a piece of ice on the hand. The sensation of burning occurs, a combination of cold, heat and pain points. Are there other sensations that are made up of several others? See Fig. III.40

Major Concept 6. The sense of taste is located in numerous taste buds on the surface of the tongue.

Concept 6-a,b (p. 35-36): (a) The taste buds in the different regions indicate the different tastes as sweet, bitter, salty, sour, etc.
(b) Nerve fibres carry the stimuli to the central nervous system.

You may think of the sense of taste as comprising a number of sentinels (taste buds) which inspect the substances entering the digestive system. These taste buds perform different functions according to their location in various regions of the tongue. Does sugar candy taste sweeter when you lick it, rather than when you chew it far back on the tongue?

Experiment with sweet, sour, bitter and salty foods to determine where these particular taste

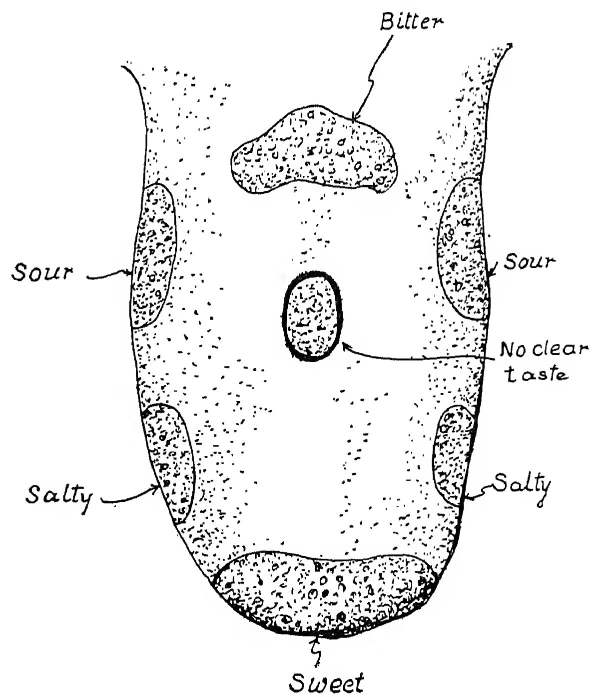


Fig. III.41. Taste map of tongue.

buds are located. Then make a taste map of the tongue. See if all taste maps are alike. Some may not agree on bitter tastes. They may say bitter things are tasteless. How do you know something is sweet or sour, salty or bitter? Free nerve endings from the taste buds connect with the liquid in the mouth.

Each of these nerve fibres connects to cranial nerves which make contact with the brain and spinal cord.

Major Concept 7. The sense of smell is located in the mucous lining of the nose as numerous olfactory buds.

Concept 7-a,b,c (p. 35): (a) Each olfactory bud is a bunch of nerve cells with hair-like endings which are stimulated by the molecules of a particular substance breathed with the air.
(b) These stimuli are carried to the brain by nerves.
(c) The organs of taste and smell work together.

Odours are air borne.

Smell an onion, a fragrant fruit like banana, and a spice like curry. You will find that the receptors in the lining of the nostrils are stimulated by the gases (vapours) of the chemicals in these substances whereas, in the mouth, the sense of taste is stimulated by liquids. Before one can taste a solid, it must become liquid. Before one can smell a solid, it must become a gas. Do you notice when you smell something like banana or onion, you almost believe you are tasting it? Our sensory judgment about a substance is sharpest when impulses from both tongue and nose reach the neural centres. The organs of taste and smell are closely related. What happens when you have a cold in the nose? Can you taste as well?

Hold your nose and taste onion juice and apple juice. Are they different in taste? What does this tell you about the sensations of taste and smell? Try some other items like powdered coffee and powdered aspirin. Make a chart of your findings. There are many intermediate odours, but odours can be broadly classified as, spicy as in cloves, fragrant as in some flowers and vanilla, putrid or rancid as in hydrogen sulphide, burnt as in tarry substances (as fresh tar on roads). Compare the sense of smell in other animals with that of man, e.g., dog and man.

Major Concept 8. The ear is the organ of hearing. It has three parts: external, middle and inner ears.

Concept 8-a(p. 35): All sounds come from vibrations of something moving back and forth.

Is there a single cause for all the sounds you hear? Crumple a paper. Feel your wind pipe while whistling. Stretch a rubber band out and pluck it with one hand. Blow over the top of a bottle. Dip your finger in vinegar and rub it around the rim of a thin drinking glass. Be sure both your finger and the glass are clean. Do you sense something vibrating? Now put water in the glass and watch the pattern formed on the surface while the sound is being produced.

Concept 8-b (p.35) : Without air around, no sound can be heard.

Sound may be carried by any media such as air, water, wire, string, etc. To demonstrate how a string may carry the vibrations of a vibrating spoon through the string to the ears, perform the experiment shown in the figure.

Fig. III.42. Making a spoon ring like a bell.

Concept 8-c (p.35) : The external ear is like a funnel which directs the sound waves down a slightly curved tube to the ear drum.

Cup a hand like a funnel about the ear and note how much easier it is to hear. The outer ear directs the sound waves somewhat in this manner and also guards the opening to the sensitive middle ear.

Concept 8-d (p.35) : Sound waves cause ear drum to vibrate.

The ear drum is set at a slant which allows a greater area for the impact of sound vibrations.

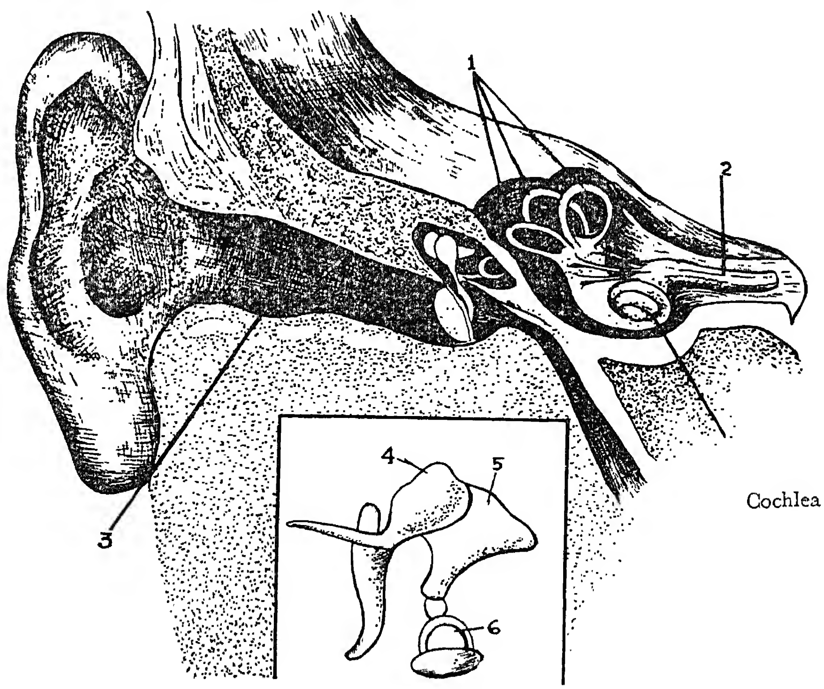


Fig. III.43. The human ear.

1. Semi-circular canals
2. Auditory nerve
3. Auditory canal
4. Hammer
5. Anvil
6. Stirrup

Concept 8-e, f (p. 35): (e) The middle ear consists of a chain of three small bones. One end of this chain is fixed to the ear drum and the other to the inner ear. This chain carries the vibrations to the ear drum.
(f) The inner ear consists of a tiny snail-shaped canal filled with a fluid called lymph and a swelling at one end provided with sensitive nerve cells.

Obtain a model of the ear and study the various parts. Some models have removable parts from which much about the structure of the ear can be learnt.

One with an artistic ability can draw an accurate picture of the ear, so that others can visualize the parts and study the functions of the various parts. Be sure the idea of the parts vibrating is made clear.

Concept 8-g (p. 35): The vibrations reaching the inner ear stimulate these nerve cells, and the impulses are carried by nerves to the brain.

Show by illustration or models how the nerve cells in the inner ear are connected to nerves which carry impulses *via* the auditory nerve to the cerebrum of the brain.

Concept 8-h (p. 35): A tube connecting the middle ear with the throat maintains equal pressure on both sides of the drum.

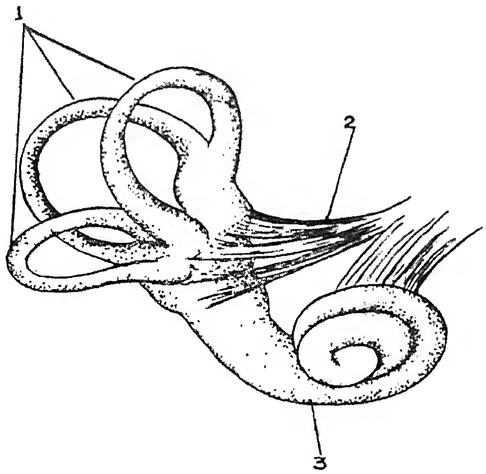
Some of you may have had ear-aches. Young children are, particularly, susceptible to ear infections because the tube (Eustachian) connecting the middle ear with the throat is wider and straighter than in adulthood. Discuss what happens when this connection is blocked by a cold—the air pressure outside is not equal to that inside. In the case of a diver the pressure outside increases as he dives. But with a blocked Eustachian tube, the middle ear pressure remains the same and the difference in pressure could damage the ear drum. What would be the case of the high altitude flier in a non-pressurized cabin?

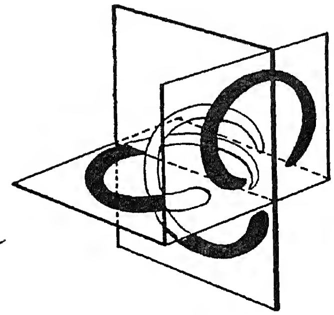
Major Concept 9. The inner ear is also an organ of balance.

Concept 9 a, b, c (p. 35): (a) The sensitive hairs in the coiled canal of the inner ear are stimulated when the head is moved in any direction.
(b) An impulse through nerves to the brain makes one aware of the movement.
(c) Stimulation of these hair cells gives the sensation of position.

Ask someone to stand up, close his eyes, and lift his right leg and answer these questions. Is your leg bent? Are your toes up or down? Ask someone else to close his eyes and bend over. How does he know he is bent over? Does he lose his balance or is he able to stand up easily?

Draw the semi-circular canals and note that they are not in the same plane, but at right angles to each other. They are filled with liquid. Sensitive hairs project into the liquid.





1. Semi-circular canals
2. Auditory nerve
3. Cochlea (snail-shaped canal)

Fig. III.44. Semi-circular canals. Inset shows angular position of semi-circular canals.

'The tip of the hairs attach to a tiny ear stone or calcium-containing body. When the stone is in a certain position, it pulls on some hairs more than others, and this stimulates the cells to which hairs are connected. Nerve impulses from these hair cells to the brain, register the particular position of the ear stone. When the head is tilted or when the balance of the body is changed, then gravity acts on all the ear stones and shifts them in a given manner. This pulls a different set of hair cells, and different sets of impulses to the brain inform of the change in balance. Reflex signals from the brain help maintain balance. This sense permits recognition of up, down, side, front and back.'*

A disease of the semi-circular canals results in dizziness and loss of equilibrium.

Major Concept 10. The sense organ of sight is the eye.

Concept 10-a (p. 36): An object is visible only if it sends light to our eyes.

How important is light to you? Try this experiment at home to find out. Blindfold yourself so that no light enters your eyes. Keep this blindfold on for an hour while you try to go about your tasks. Do you have troubles getting about a familiar room? Is it difficult to eat? Can you play ball or sew?

How do you see a rose? Light must go to the object, then the object must reflect light back to your eyes. 'Reflect' means 'throw back.' Light rays enter the eye, cross the lens of the eye and focus on the retina. Why is the image inverted on the retina? What do you know about light? (This will be developed under Unit VI, class VIII, Light—A Form of Energy.

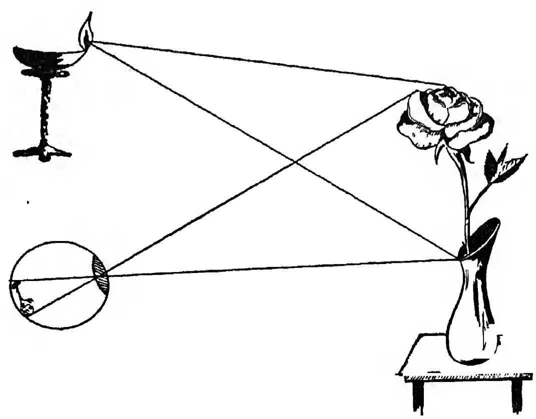


Fig. III.45. Formation of image in eye.

*WEISZ, *The Science of Biology*, McGraw Hill, 1959, page 491

Concept 10-b,c,d,e,f, (p. 36):

(b) Each eye is shaped much like a ball. It is set in sockets of bone in the skull.

(c) Additional protection is provided by eyelids and eyelashes.

(d) Ease of movement is provided by muscles attached to the eye-ball.

(e) The eye has three coats, the outermost of which is a tough white coating known as the white of the eye. The front of this, called the cornea, is transparent and acts like a window.

(f) The middle, or choroid layer, is richly supplied with blood vessels. It is a complete layer except for a small opening in the front called the pupil.

1. Observe a person's eyes at close range. What colour are they? Where is the colour? How many parts of the eye can you see and name? What is the dark round portion of the coloured area? Is it a hole? Have someone close his eyes for a while and then look at this dark area (the pupil). How has it changed? What are the parts of the eye you cannot see?

2. Obtain a model of the eye to study its parts. Then make models of the eye either with plasticine or papier mache. Some artistic person may wish to draw an accurate picture for use by the class.

3. How does the lens of your eye work? Hold up a magnifying glass (lens) so that the light from the window will pass through it. On the side away from the window hold up a flat piece of white paper. Move the lens (magnifying glass) back and forth slowly until a picture forms on the paper. In your own words relate this to how the lens in your eye works.

Concept 10-g (p. 36): The choroid layer round the pupil, called the iris, is pigmented and regulates the size of the pupil.

You have heard the eye compared to a camera in certain respects. Bring a camera to explain how a photograph is taken.. How do the eye and the camera differ? In a camera the picture is recorded on the film in the back of the camera. In the eye, the image is recorded on the retina and interpreted by the brain.

In a camera when you focus light rays on a film, you change the distance between the lens and the film surface. In the eye, focussing on the retina is accomplished by change in the shape of the lens.

What other differences can you find? Do the eyelids and the shutter really work alike? If you damage a camera, you can replace it. What about your eyes?

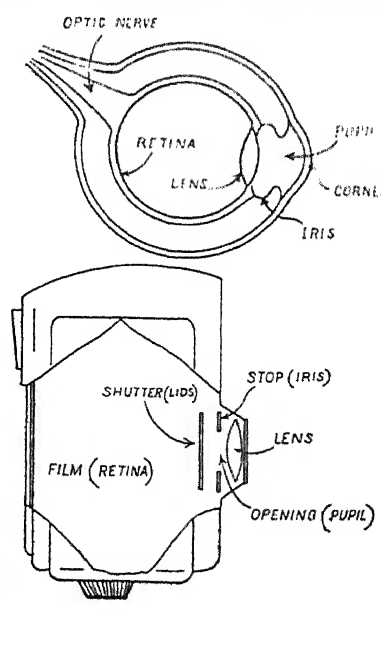


Fig. III.46. Comparison of the structure of the eye and the camera.

TABLE III-9 THE EYE AND THE CAMERA

Parts of the eye		Parts of the camera
Eyeball	corresponds to	camera box
Lens	,, ,,	lens
Lids	,, ,,	shutter
Iris	,, ,,	diaphragm
Lens muscle	,, ,,	focussing devices
Pigment of choroid, retina	,, ,,	black lining
Retina	,, ,,	light sensitive film

Find out about 'seeing-dogs' for the blind. How do the blind learn to read by the Braille method? What is an Eye-Bank?

Concept 10-h, i (p. 36): (h) The innermost layer is the retina which receives the light.
(i) Behind the pupil is a lens which forms an image at the back of the retina. This image is carried by nerves to the brain where it is translated.

You see a beautiful scene. How do you see what you are seeing? Go through step by step from the point where the scene is illuminated by some source of light and light from the object is reflected to your eyes. What structures of the eyeball do the light waves pass through on the way to the retina? What are the next steps? Use a model or diagram to give meaning to your explanation.

CONTROL OF DISEASE

Major Concept 1. Antiseptics are substances that prevent blood poisoning.

Concept 1-a (p. 36): Bacteria entering a wound may cause blood poisoning.

1. Bacteria stay alive in much the same way as you do. They take in food, digest it, carry on oxidation, release energy, give off waste, grow and reproduce. They require favourable conditions of moisture, moderate temperature, darkness, and food. They can divide in a matter of minutes. It would not take long to have a big colony. Describe how a wound could become infected. If a bacterium divides into two every fifteen minutes, at the end of the first hour there would be 16, and at the end of five hours, there would be 10,48,576 bacteria. Each hour the number increases sixteen times. How many would there be at the end of ten hours? If we represent the number of bacteria by spheres, the diameter of the spheres will increase approximately 2.5 times each hour; 100 times in five hours. Draw circles to scale that represent the number of bacteria to begin with, at the end of one hour, 2 hours, 5 hours and 10 hours.

2. Try growing some bacteria. You will have more success if you grow them on a culture medium. There are several ways.

A. Boil a potato. Sterilize a knife and several jars. Slice the boiled potato with

sterile knife. Without touching with the fingers, drop a slice of potato in each jar. Close at once.

Quickly remove the cover of each jar and touch the potato in it with one of the following:

A bit of dust, a drop of saliva from one who has a cold, a few drops of water from the street, a used comb. You will think of other sources of infection. Keep one jar as a control.

Put the jars in a warm dark place. Observe them daily. Do not touch the covers. Watch for colonies of bacteria to develop. Are there any mould colonies growing ?

If you wish to examine the bacteria under a microscope, put some of them on a glass slide with a sterilized needle. Then hold the needle over a flame. Do not touch any of the potato slices. Always sterilize your jars when you complete your experiment.

B. Materials needed: Beakers, tripod, heat source (as Bunsen burner), Petri dishes or substitutes, funnel, clean cloth, beef extracts, commercial agar (china grass).

Procedure: Wash the Petri dishes (Culture dishes) in hot, soapy water and then rinse well. Boil the dishes in water for 15-20 minutes. Take them from the hot water and turn them upside down to drain on a clean piece of towelling paper. Dissolve a bouillon cube in 500 millilitres of hot water and add 15 grams of commercial agar. Heat and stir until all the agar is dissolved. Put a piece of clean cloth over a funnel and filter the solution into a clean beaker. Boil the clear solution for 10-15 minutes. While the solution is still hot, pour a little in the bottom half of each Petri dish. Put the cover on each dish immediately and shake the dish to spread the agar solution into a thin film on the bottom. This amount of solution should be enough to prepare 25 to 30 culture dishes.

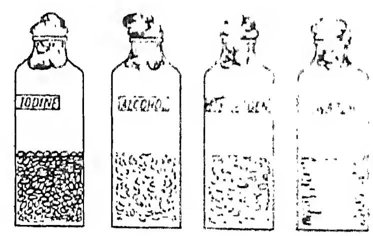
Observations: Why were the Petri dishes boiled in hot water before using ? Why was the agar solution boiled after filtering ? Would you expect to find any live bacteria in the prepared Petri dishes? What is the purpose of the agar film on the bottom of each dish ? Recall what bacteria need for living.

Concept 1-b, c (p. 36): (b) Antiseptics do not kill bacteria but check their multiplication and growth.
(c) Dettol, carbolic acid, spirit, tincture of iodine are some of the commonly used antiseptics.

Test the effect of some antiseptics. Soak some bean seed for several hours. Take four bottles. Place several beans in each test tube with enough water to cover. Add a teaspoonful of tincture of iodine to the first bottle and label it I.

Add a teaspoonful of alcohol to the second one and label it A. In a third bottle add the same amount of hydrogen peroxide and label it H. Add nothing to the beans in the fourth bottle W. Cover all the bottles well. After several days remove the stoppers and smell each bottle. A foul odour will indicate that bacteria are active. Which antiseptic worked best ?

Antiseptics such as dettol, carbolic acid (for teacher's use only), and others may also be tried.



I A H W

Fig. III.47. Testing the effects of the antiseptics.

I=Iodine A=Alcohol W=Water H=Hydrogen peroxide

Whenever you have a wound, wash it gently with warm soapy water. Then find out what antiseptic is best to use. Your parents should know about minor cuts; in case of a deep wound, consult a doctor.

Major Concept 2. Disinfectants are used to kill germs in homes or environment.

Concept 2-a, b (p. 36): (a) Disinfectants are not used in or on the body.
(b) Lysol and bleaching powder are some common disinfectants.

Do you use disinfectants to clean the floor in your house? What disinfectants do you use? How are they used?

Find out what chemicals are used most often for disinfectants. Your chemist will assist you.

Major Concept 3. Certain drugs kill bacteria within the body without harming the body.

Concept 3-a (p. 37): Sulpha drugs are effective in stopping infections in wounds and in blood streams.

In 1962, a certain dye, prontosil, was discovered which could kill many germs without injuring the person greatly. Only part of the dye was needed for this. This part was the very first *sulpha drug*. It is believed that sulpha drugs only slow up or weaken bacteria and do not kill them. The white blood cells (phagocytes) and the antibodies in the body do the rest. There are many different sulpha drugs today and none should be taken except as prescribed by a doctor.

Many of the sulpha drugs are effective in combating respiratory infections.

Concept 3-b, c (p. 37): (b) Antibiotics are substances made by bacteria or moulds which kill micro-organisms.
(c) Penicillin, aureomycin, streptomycin, chloromycetin are antibiotics effective in the control of many diseases; penicillin controls pneumonia and other diseaees; chloromycetin cntrols typhoid fever; streptomycin controls tuberculosis.

1. Place an orange in a jar with a moist piece of paper or cloth over it. Cover the jar with a clean cloth and keep the paper moist. If kept in a warm, dark place, a blue-green mould will grow on the orange in a week or so. Examine a little of this mould with a lens or place some on a slide under a microscope. Describe what you see.

2. Find out about Sir Alexander Fleming and his discovery of penicillin, the first of many antibiotics. 'Antibiotic' means *against life* (of disease organisms). Today penicillin which is many times more effective is available at low cost.

3. Here are some of the antibiotics you will want to find out about.

TABLE III—10 SOME ANTIBIOTICS AND THEIR USES

Antibiotic	How and when discovered	Use
Streptomycin	By a soil chemist working with soil fungi. 1944	Tuberculosis, some forms of pneumonia, syphilis.
Aureomycin	1948	Meningitis, whooping cough.
Chloromycetin	1947	Typhoid fever, spotted fever, virus pneumonia.
Penicillin	1947	Some forms of pneumonia, syphilis. Wound infections Osteomylitis.
Terramycin	1950	Meningitis, whooping cough.
Erythromycin	1950	Uses akin to penicillin

Check with a chemist or doctor for more information on antibiotics. Research is still going on today on this subject and this is an exciting field of endeavour.

Use the culture media you made in 1-a of this unit. After your germs are growing well, put some penicillin powder obtained from a chemist on the colony of bacteria. Observe what happens. You should be able to see an area where the bacteria have disappeared.

Major Concept 4. Immunization practices such as inoculation and vaccination prevent the spread of certain communicable diseases.

Concept 4-a (p. 37): The inborn ability to resist diseases possessed by our body is called natural immunity.

1. Have you had any contagious disease ? Do you have more colds than your friends ? Some people have more boils and pimples than others. Studies show that races differ in being prone or susceptible to disease. Dark-skinned people are less susceptible to malaria and to hookworm than white races. On the other hand, white races are less susceptible to tuberculosis and measles than dark races. Human beings are quite immune to diseases that are serious or even fatal to birds or cattle. (There are several exceptions to this such as bovine tuberculosis which may be transmitted to man through milk). Such immunity is called *natural immunity*. This immunity may be weakened or destroyed by various conditions. Also this natural immunity may be aided by inoculating a person with suitable substances to develop antibodies in the blood. These antibodies work in various ways against the invading disease germs.

2. How can a doctor tell if you are immune to certain diseases ? Find out about the Shick Test for diphtheria, tuberculosis test, etc.

Concept 4-b (p. 37): Immunity against small-pox is achieved by vaccination.

Have you been vaccinated for small-pox? What does this mean to you? Were you ill after being vaccinated, while your body was building small-pox antibodies? Look up the life story of Edward Jenner (1749-1823). Read about the history of inoculation or vaccination. Were people afraid of inoculation?

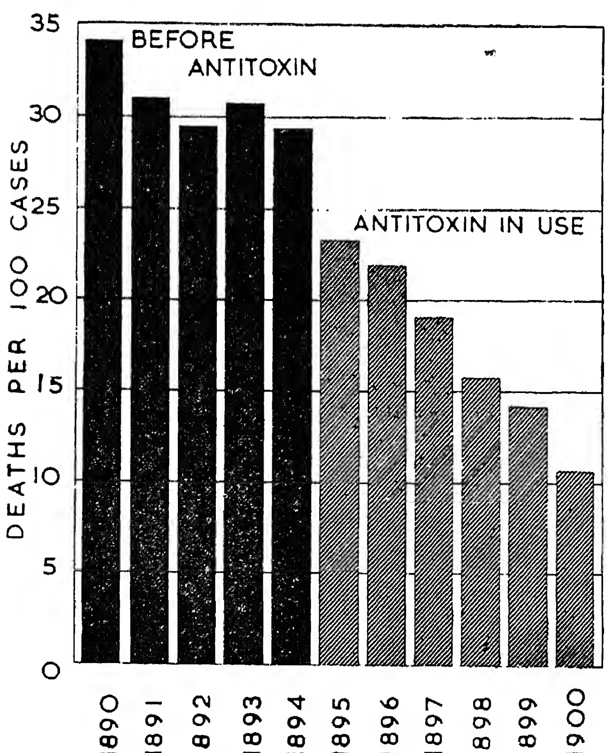
Jenner introduced active germs into a person's body to stimulate that body to develop something in the blood (antibodies) to fight the disease of small-pox.

Has there been a recent outbreak of small-pox in your community? Are most of the people vaccinated each year?

Concept 4-c (p. 37): Inoculations are used to prevent cholera, typhoid, typhus fever, yellow fever, diphtheria, and tetanus.

1. Discuss the disease, cholera, its causes and the inoculations for it. Have you been inoculated for cholera? For typhoid? Diphtheria? Yellow fever?

TABLE III-11. HOW DIPHTHERIA ANTITOXIN SAVED LIVES



The chart shows the number of deaths from diphtheria in a London hospital five years before and five years after the use of antitoxin.

Study the accompanying graph. State in your own words the control of the disease diphtheria after antitoxin was introduced.

Find out about other diseases that have been controlled by inoculations.

2. Interview a public health officer on the subject of inoculations and the control of diseases.

3. Did you ever hurt a toe or finger with a rusty, dirty nail? Did you have an inoculation for tetanus? Find out about tetanus (Lockjaw).

4. Look up the story of yellow fever and how it can be controlled.

Concept 4-d (p. 37): Vaccines are derived from the micro-organisms that cause the disease.

1. The body may protect itself from disease by producing antibodies which may act in opposition to the disease producing organism or neutralize the poison (toxins) produced by it.

The word vaccine is derived from the Latin word 'vacca' for cow. Upon checking the history of disease control, you will know this word, which took root when Jenner used cowpox pus in treating small-pox. Today vaccines are prepared under carefully controlled laboratory conditions. They must be strong enough to cause the body to produce antibodies, yet weak enough to be safe for use. Vaccines vary with the nature of the organism or product involved. They may contain weakened or dead bacteria, weakened viruses, or living bacteria in small numbers. They give the person a mild form of the disease so that antibodies will be produced. In some countries, babies and children are given shots (inoculations) to build up their immunity to diphtheria, tetanus, whooping cough, and polio. Seldom is there an outbreak of any of these diseases in such a situation.

2. Find out about Dr. Jonas Salk and Dr. Sabin and the vaccines developed for the disease, poliomyletis.

Major Concept 5. Milk may carry micro-organisms causing tuberculosis, typhoid, undulant fever, amoebic dysentery, diphtheria, cholera and other diseases.

Concept 5-a(p. 37): Milking and handling of milk should be done under hygienic conditions.

1. Set up a committee to find out from the Public Health Authorities or a local doctor what diseases can be transmitted by milk. Find out if there have been any recent milk-borne epidemic.

Find out what is done to protect you from impure milk, food and water.

2. If possible, have a group visit to a dairy to report back to the class how the milk is pasteurized and bottled. If possible, let the whole class visit the dairy.

Concept 5-b,c (p. 37): (b) Milk should be pasteurized before drinking. Pasteurization kills disease germs.

(c) The process of pasteurization consists in:
heating milk up to 160°F (71°C) for one minute, or
heating up to 150°F (66°C) for 30 minutes and rapidly cooling it to 50°F. (10°C)

Look up the story of Louis Pasteur and see how his research relates to your life today.

See if heated (pasteurized) milk will keep longer without souring than unheated milk. Take

several containers preferable test tubes. Clean these thoroughly. Number each container. Fill these with raw milk, plugging each one with cotton to keep out the air. Now place one half of the containers in a heat proof dish (beaker) with water up to the milk level. Put a thermometer in a container of milk without removing the cotton plug. Heat the water in the beaker until the thermometer registers 66°C (150°F) for 30 minutes. This process is called pasteurization. Cool quickly (why ?) to 10°C (50°F).

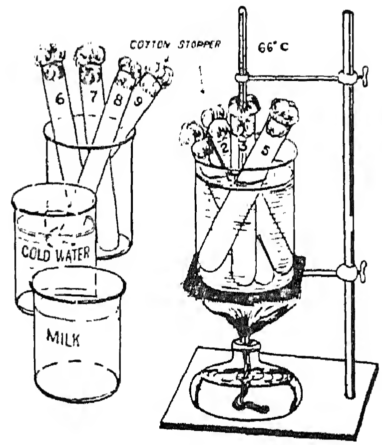


Fig. III.48. Pasteurization of milk.

Concept 5-d (p.37): Pasteurized milk should be delivered to the consumer in sealed bottles.

Why should pasteurized milk be sold in sealed bottles ? How is milk handled in your neighbourhood ?

Major Concept 6. Anaesthetics are substances used to make surgical operation painless.

Concept 6-a, b (p. 37) (a) Ether, chloroform and nitrous oxide gas are common anaesthetics used to make operations painless.
(b) Cocaine, novocain and others are used as local anaesthetics.

1. Have you ever been anaesthetized ? Have you had your tonsils out ? Have you had an operation ? Did they put you to sleep? Anaesthetics are substances to make a person unconscious of pain. They must be chosen to suit a particular case. A doctor selects his anaesthetic just as carefully as he writes a prescription for drugs.

The person who gives the anaesthetic is a highly trained person. Why is this so ?

Anaesthetics may be general which make the person unconscious, or local where an area is blocked off to make it insensitive to pain (as cocaine in tooth filling), or spinal where the anaesthetic is given between certain vertebrae causing temporary loss of feeling in the areas reached by those nerves branching from that spinal region.

2. Interview a surgeon on the use of anaesthetics.

3. Read the story of the discovery of ether as the first pain-killer.

4. Find out about nitrous oxide gas, called 'laughing gas', for its exhilarating effect on people.

UNIT IV SAFETY AND FIRST AID

CLASS VI

Major Concept 1. The habit of anticipating accident and practising preventive measures is part of civic responsibility.

Concept-1 a, b, c (p. 40) : (a) Fire hazards should be eliminated.
(b) Traffic hazards should be eliminated.
(c) Adherence to traffic rules prevents accidents.

The word accident is derived from *accidere* to happen from *ad+cidere* (*cadere* to fall). In other words, people used to believe accidents happened despite anything they could do about it. Would you agree with this? 'No', you say, but our language belies this. Have you heard this: 'The knife slipped and cut me', or 'The bicycle skidded and I fell'. Of course, you know better.

Do you anticipate accidents? To do this, you need to know how and where accidents occur. Let us look at places familiar to you, in the home and going to and from home by foot, car or bicycle.

A. Can you *see* danger?

1. Test yourself. Can you distinguish among red, orange and green lights? Get a variety of coloured articles such as paper, yarn and flowers, and get a set of standard colours. Give each colour a number. Now write on a card all the flowers, pieces of yarn, and paper you think are green, or red, or orange. You may find other colours used in warning signs, thus increasing the difficulty of the test. Test the whole class. Ability to recognize change in colour is also important in judging the freshness of food.

2. Take a vision test. Can you read fine print in a book at 18 inches from your eyes?

3. Can you recognize relative distances? Can you judge how high a stair-step is or how far away a car is? Fasten two bright objects, such as a flag or an apple, to one end of two strong sticks about a yard long. Thrust the free ends of the sticks into the ground about two metres apart. Walk 20 metres away. Turn your back. A friend has moved one stick 50 cms. or so nearer to you than the other. When you turn around to look, can you tell which is nearer? Test your friend in this way. Vary the distances.

The better your eyes can identify colours, recognize shapes at a distance, and judge relative distances, the less likely you are to have some kind of accident.

4. Can you see in the dark? Try coming from a well-lighted area to a dark one. How fast do you adjust? Many accidents occur in poorly lit areas such as yards at night where objects are lying around, where a rope is hanging low across the way, where boards with nails or up-turned tools like rakes are left carelessly about.

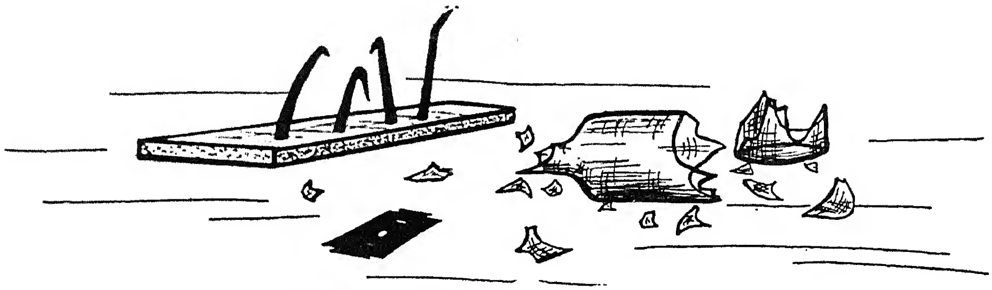


Fig. IV.1. Sharp objects cause accidents.

If you walk on a road at night, always wear white or light colours. You may see the lights, but the driver may not see you.

B. Can you *hear* danger?

1. Do you hear well? Try some simple hearing tests. Plug one ear with cotton. Have a friend bring a watch near until you hear it ticking. Now let him move it away until you no longer hear it. Test the other ear. Do you notice a difference in the distance at which you did not hear the ticking? Test your friends. Which of your friends do you think will be most reliable in hearing a danger signal?

2. Place your ear against a table. Place the watch some distance away. Have your friend move it towards you. When can you hear it ticking? Is this distance greater than when you heard it in the air? Try your ear against other things. In the dark you depend greatly on your ears. Can you tell from echoes when you are driving past objects or spaces? Blind people listen to echoes to get about.

3. Can you hear very high-pitched sounds? Your dog can hear perhaps on octave higher than you can. If you can hear high-pitched sounds, it may save you from accidents, as some machine noises indicating faulty lubrication are high-pitched. Some insects and pests make high-pitched noises. Can you hear fire crackle at considerable distance?

C. Can you *smell* or *taste* danger?

1. Explore the medicine chest at home. How well can you identify what is there by smelling? Everything in a medicine chest should be labelled. But even with labels, you should use your sense of smell as an additional check. All poisonous medicines should be kept on a high shelf, so that you unconsciously learn to leave them alone. Check your home medicine chest. Has this been done?

2. Train your nose to detect odours like fire, smoke, fuel gas, leaking gasoline, naptha, and other common substances about the house. Of course, one of the most dangerous gases, carbon monoxide, is odourless. Never stay in a car in a closed place, with the motor running. Always keep a window open a little in a house where charcoal burners are operating. Do not trust your nose in this case. Learn the danger signs when people are breathing unsafe air. Some people get sleepy, others get pale, fidgety, or they perspire or faint.

Smoke is less dense near the floor in a smoke-filled room. This knowledge may help you in a fire.

3. Learn to know the odour of spoilt foods, and avoid accidents from food poisoning. Take a few samples of milk, meat, eggs, and other foods. Keep some fresh and allow others to spoil to varying degrees. Train your sense of smell to identify these odours.

4. Let your shopkeeper know you will not buy his uncovered meats, sweets, and other food stuffs. Why? He may not realize what colonies of microbes are growing on the food and spoiling it.

5. All fruits and vegetables should be washed in water to which a very small amount of potassium permanganate or Lugol's solution have been added. This is a safety measure where poison sprays for insect pests have been used and where the vegetables have been grown in soil fertilized by human excreta (waste).

6. Always boil drinking water when uncertain of the source of the water.

Fig. IV. 2. Exhaust gases are poisonous.

D. Can you *feel* danger?

1. Could you avoid accidents if you could not see, hear or smell? Have you ever awakened a sleeping person by touch when sounds, odours and light did not disturb him?

Are you careful about how you touch an animal? A timid touch may startle a horse, cow or dog whereas a firm confident pat may keep the animal from striking out at you. Never go up behind an animal. On farms, nearly one-fourth of the accidents are caused by farm animals.

2. Your sense of touch will help you feel temperatures and keep you from being burnt. You can also feel how sharp a tool is and avoid being cut. When you climb down a ladder, do you feel with your feet where the rungs are?

3. Some people are able to identify things with their feet; perhaps you have done this while swimming.

4. Slippery floors and loose rugs cause falls. Can you sense slipperiness? Many fatal accidents are caused by falls.

E. How good is your judgment?

1. You may have perfect vision, hearing and other sharp senses, but do you use your intelligence in anticipating accidents? Have you ever slept in a strange room? Did you try yourself out in the dark? Put out the light. Can you locate the bed? the light? the door? Turn about several times. Can you still do it? Constantly test your ability to judge and remember distances and directions well. In a time of war or crisis, this may be invaluable to you and others.

2. Make a list of the accidents you have had or have read about, which were due to failure of people to judge distance, direction, and other things which they cannot hear, smell, or feel.

3. Can you judge weights well? Anyone who tries to lift more than he should can tear ligaments and injure muscles. A general rule is that the load that you carry should weigh less than 35% of your body weight. Many girls and women lift more than they should. Some parts of the world have limited weights of loads for women labourers to 25 pounds (12 kg.) and to 10 pounds ($4\frac{1}{2}$ kg.) up and down stairs rising more than 5 feet ($1\frac{1}{2}$ meters). Learn to lift weights safely. Stand with your feet fairly close together. Never hold your shoulders lower than your hips. Use your leg muscles rather than back muscles when lifting heavy things.

4. Make a check-up on how you react to danger. Are you unable to move a muscle when afraid? Or do you try to remain calm in the face of danger? Do you try to anticipate dangers and act accordingly? Are you one to take a foolish dare for fear someone will think you weak? Or do you use your intelligence to keep alert and to help others do likewise? The first lesson of safety is to learn what you can and cannot do safely.

Major Concept 2. Practising what is known and continuing to learn what to do in first aid and emergency situations is essential to survival and to good citizenship.

Concept 2-a (p. 40)**:** Electrical equipment should be handled after switching off the current.

What electrical equipment do you have in your classroom? What do you have at home? How do you use it? Test yourself out on these safety rules and see if you can explain to a younger student why they are important.

1. Never grasp an electrical device that has just been in use. (Most electrical devices are hot after use, and burns result).

2. Disconnect all electrical appliances when not in use. Do not risk a shock.

3. Electrical extension cords used for projectors, etc., should be inspected regularly for defects of insulation and connection. (Fires can be caused by poorly insulated devices).

4. Never handle two electrical appliances at once. Do not turn off a radio while telephoning.

5. In pulling a cord from an electrical outlet, pull on the plug attached to the end. Never pull on the cord itself. (You may sever the plug from the cord and get a shock).

6. Always switch the current off before handling electrical equipment. (You will eliminate the possibility of a shock).

7. Never use the electrical outlets in your home for your science experiments. Use dry cells or batteries.

8. Never touch an electrical appliance with wet hands. Also be sure not to touch it if any part of your body is against a water pipe or faucet.

9. Always fix a loose electrical connection. Cover the bare wires with insulation.

Concept 2-b (p. 40)**:** Bleeding can be prevented by pressure on points or by ligature.

Three life-saver steps in first aid are:
(1) stop the bleeding:
(2) protect the wound:
(3) prevent or treat for shock.

People do get hurt and there may be no doctor present.

1. *Stop the bleeding*: Uncontrolled bleeding may cause shock and finally death. To stop bleeding, place a first aid dressing or a sterile piece of linen over the wound and exert firm, evenly distributed pressure on the dressing with the palm and fingers of the open hand.

This pressure directly on the wound will compress the bleeding vessels thus reducing the

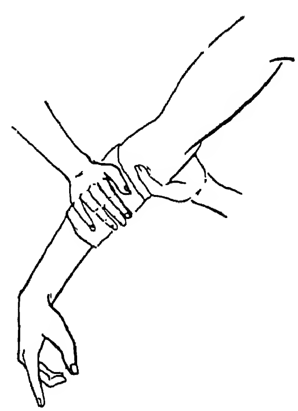


Fig. IV.3. Direct pressure to stop bleeding.

flow to the wound area; it also helps to hold the blood in the wound until clotting can occur.

After 5 to 10 minutes, the pressure of the hand can be replaced by the ends of the dressing wrapped around the injured part.

2. An additional measure used to help stop bleeding from an arm or leg is to have the injured person lie down with the leg or arm higher than the rest of the body. (If the arm or leg is fractured, do not do this until splints are applied). You will still have to use pressure over the wound as some blood will still flow through the arm or leg.

3. If the blood does not slow down by use of either pressure, bandaging or elevation of limb, then a tourniquet may be applied. Since unnecessary use of the tourniquet is dangerous, use this method only as a last resort. In all cases place it around the upper arm below the armpit or around the thigh below the groin. The rule is *a tourniquet should be placed between the wound and the body*. Once a tourniquet is applied, get the injured person to a doctor immediately. No amateur should loosen a tourniquet. Let a medical man do this as he knows how to replace lost blood. Inspect the tourniquet frequently to see if it has slipped, or if bleeding has not stopped.

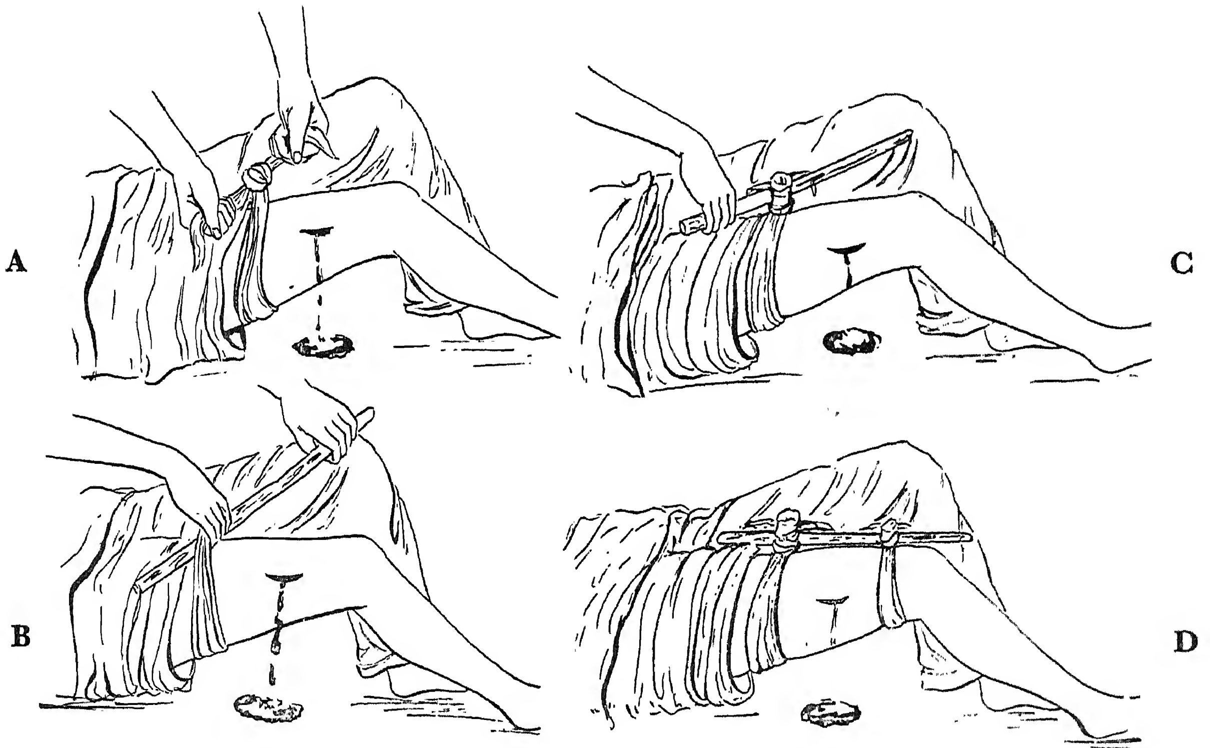


Fig. IV.4. Control bleeding with tourniquet.
A. Make loop around limb. Tie a half knot. B. Pass a stick under the loop. C. Tighten tourniquet just enough to stop bleeding. D. Bind free end of stick to keep tourniquet from unwinding. Get medical aid.

In cold weather patients with tourniquets are subject to injury by cold, so protect them from the cold.

4. Be sure you have a copy of the Indian Red Cross First Aid Manual for reference.

Concept 2-c (p. 40): Warmth, fresh air, hot drinks and a cheerful atmosphere are necessary for treatment of shock.

Have you seen a person in shock? He may tremble and appear nervous; he may become very pale, wet with sweat, and may faint. Shock may not appear immediately *with* the injury. Treat

the injured person for shock *before* it occurs. Think what you would do before you read any of these aids.

1. Loosen belt or any tight clothing.

2. Handle patient gently; move him as little as possible.

3. If he is lying in an abnormal position and there are no fractures, place him gently in a more comfortable position.

4. If there is no head, chest, or jaw injury, place his head lower than his body, so that blood may flow freely to the brain. A pack of rolled clothing beneath his feet may accomplish this, or even sloping ground may suffice.

5. Wrap him in a blanket or some extra clothing. Put something beneath his body to shield him from the cold ground.

Fig. IV.5. Treating a person in shock.

6. If he is unconscious, place him on his side or belly to prevent him from choking on blood or fluids.

7. If he is conscious, give him a warm stimulant (tea, cocoa, coffee). If he has a belly wound, do not give him a drink. Remember, alcoholic drinks are *not* stimulants.

Major Concept 1. Setting an example by practising safety precautions is an important duty of every good citizen.

Concept 1-a,b (p. 40) : (a) Obeying safety precautions when handling dangerous objects encourages others to do likewise.
(b) Obeying traffic rules encourages others to do likewise.

1. Hold a class discussion on what you as a young citizen can do to set an example of one practising safety.

A. Setting an example for safety at home.

(1) Review what you know about safety in handling electrical apparatus and equipment. Review suggestions in class VI, Concept 2-a.

(2) Check your medicine chest with your parents to note poisons and their placement out of reach. Remove unlabelled bottles or boxes.

(3) Check on your water and milk supply. Is it safe? Are your water and milk boiled?

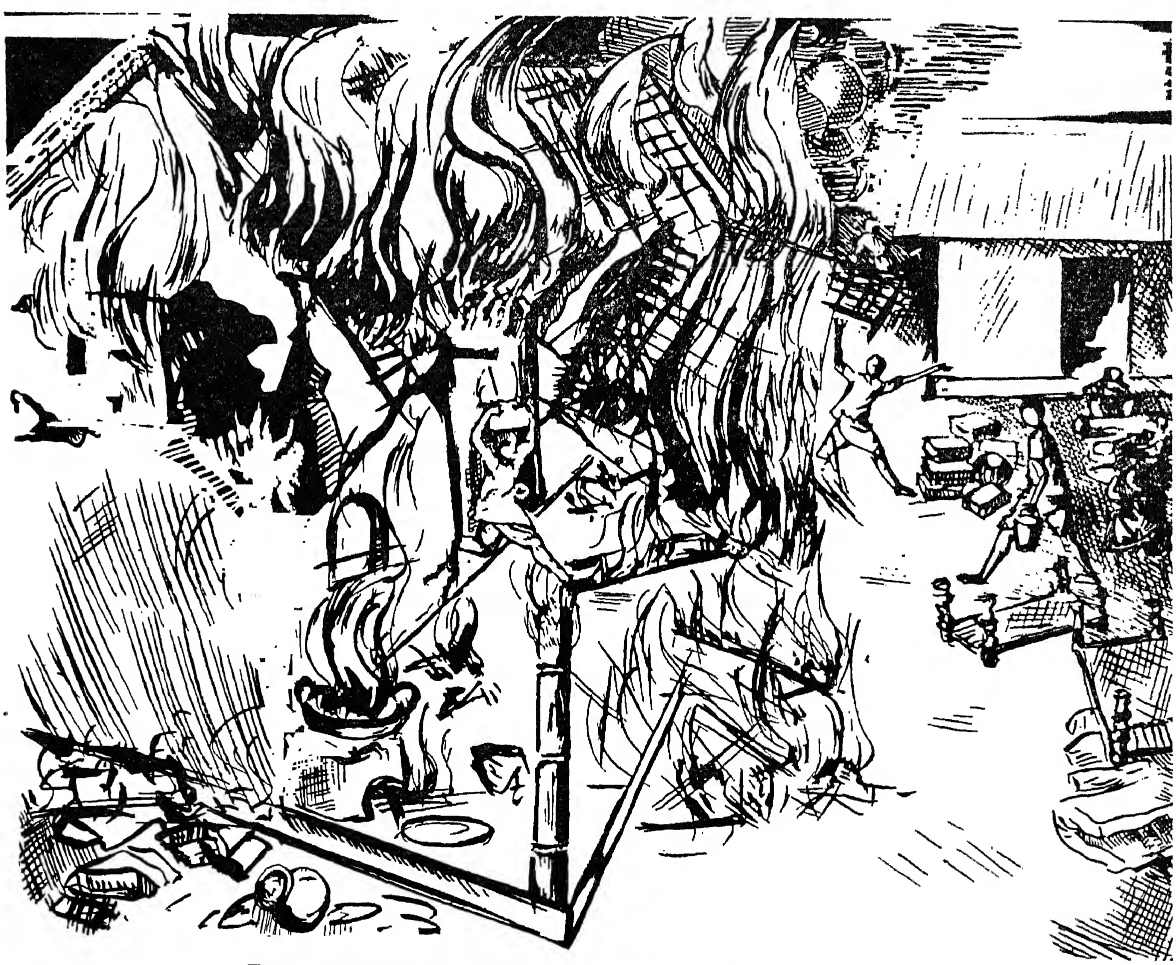


Fig. IV.5. Store all fuels (anything that will burn) carefully.

(4) Are there fire hazards about your home? Do you observe the following precautions?

(*a*) If you live on a second floor, in case of fire, plan to close your bedroom door as :this will hold back flames for a time.

(*b*) Keep a strong rope handy for an improvised ladder.

(*c*) Rehearse with the family what each is to do in case of fire. Instruct them on all possible means of escape under varying conditions.

(*d*) If sleeping in a hotel or unfamiliar surroundings, learn where the exits are. Do this in public buildings, such as movie houses.

(*e*) Never leave debris of any kind about the house; especially rags used in painting or cleaning.

(*f*) Keep matches away from young children.

(*g*) Use clearing fluids only out-of-doors.

(*h*) Never add petrol and kerosene to a fire. The hot fuel may cause the petrol or kerosene to evaporate and mix with the air near the fire. This air-gas mixture will explode.

B. Setting an example of going to school safely.

1. Show how you would teach a younger member of your family about traffic rules. Is it best to face the oncoming traffic? Why? Where is it safest to cross a street? If you look both ways before crossing a street, which way would you look last? What colour would you wear to be seen easily? Discuss Fig. IV. 6 for possible dangers.

2. Show how you would teach riding safely on a bicycle.

(*a*) Learn all the hand traffic signals. Use them always.

(*b*) Never hold on to another vehicle while riding a bicycle. Ride only one on a bicycle, if possible.

(*c*) Do not ride two abreast. You are a hazard to other traffic, and in danger yourself.

(*d*) Keep a safe distance behind all vehicles. At low speeds a safe distance is the length of one vehicle.

(*e*) Have a white light on the front and a danger signal on the rear for night driving. Wear white at night.

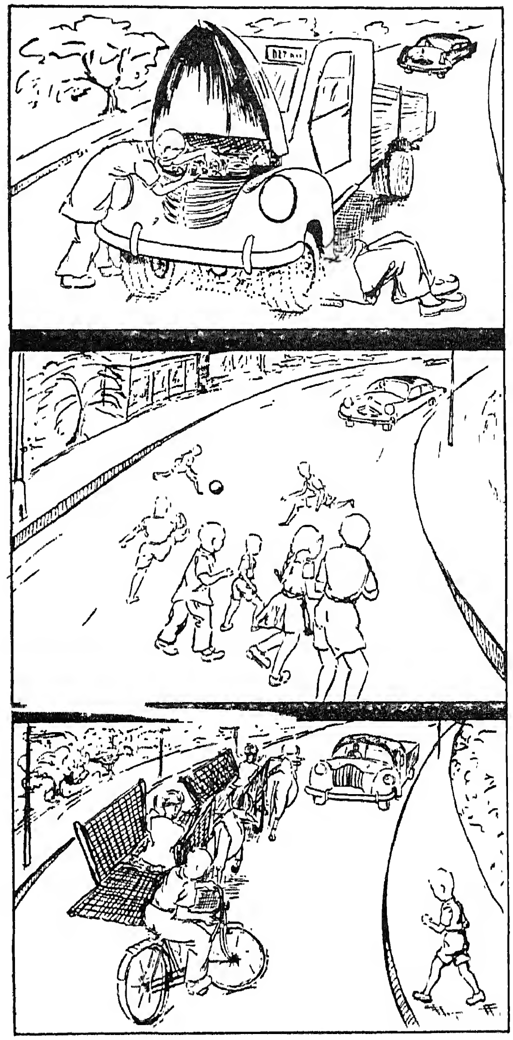


Fig. IV.6. Traffic safety.

(*f*) Give pedestrians the right of way.

(*g*) Look out for cars pulling into traffic. Keep an eye out for the sudden opening of car doors.

(*h*) Be sure your brakes are operating well.

(*i*) Slow down at all street intersections. Look to the left and right before crossing.

(*j*) Ride in a straight line. Do not weave in and and out of traffic.

(*k*) Observe all traffic lights. Move only on the green.

3. Some day you may drive a car. You will have to observe what good and poor driving is. Study the accompanying figure carefully. It may save your life some day.

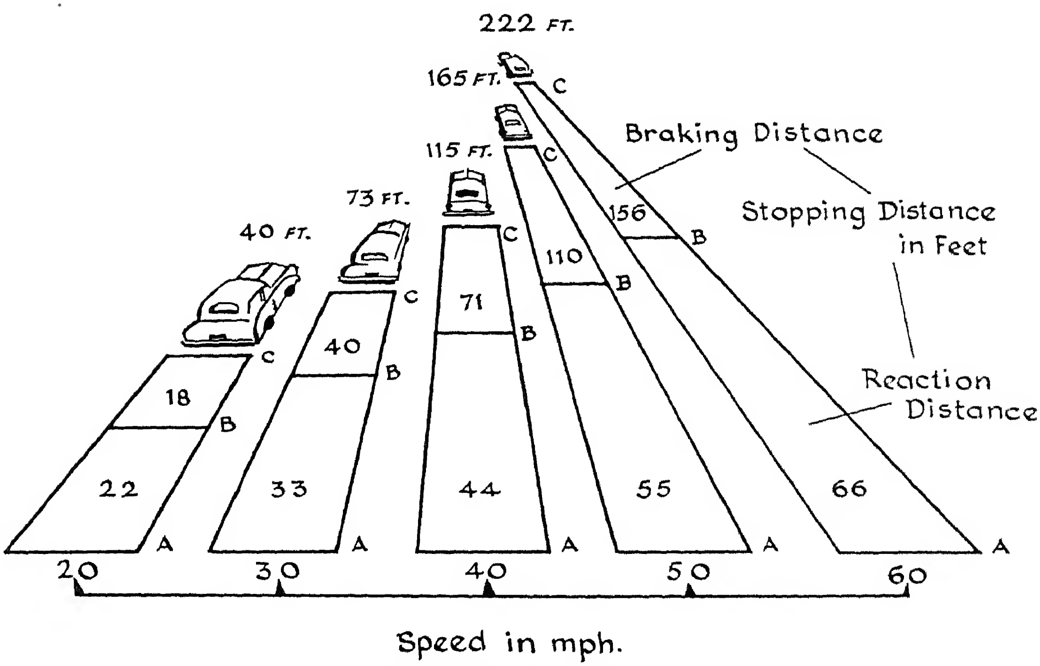


Fig. IV.7. Breaking distances related to car speed.
The faster a vehicle is moving the more difficult it is to stop it. A vehicle travelling 40 mph. will go four times as far before stopping after the brake is applied, as one travelling 20 mph.

C. Setting an example for safety at school.

1. In the classroom:

Avoid sneezing or coughing. When you do sneeze or cough, always place your handkerchief or hand over your mouth and nose.

Avoid reading in a poor light. Hold your book up while reading.

2. In the halls:

Avoid running, pushing or crowding. If you have a drinking fountain, never place your mouth on it. Avoid using public cups and towels. Never push someone's head down when he is drinking at a tap.

3. On the playground:

Watch where you are throwing or going. Be alert to any thrown items such as balls, javelins, bats, etc. Always observe the rules of the game. (*e.g.*, hockey players must keep their sticks down).

4. In the laboratory:

(*a*) List the items one should handle with care, such as denatured or wood alcohol (especially when near a flame), apparatus left hot by use, as hot projectors, carpentry tools, electrical apparatus and equipment, glassware, chemicals (never taste these and wash your hands after using), glass wool and steel wool (to avoid splinters).

(b) Never allow any unlabelled bottles in the laboratory.

(c) Make a safety rules plan for your laboratory. Illustrate it. Obey the rules.

5. On field trips:

Be sure there is a first aid kit with you. Be sure you know what to do in case of minor injury. Be sure you recognize poisonous snakes and poisonous plants. Have someone study each of these as a project and bring the information to the class before the trip.

Get acquainted with The Indian Red Cross First Aid Manual.

6. Develop with a committee a set of safety rules for your school. See that they are discussed by all classes, are printed or cyclostyled, and are placed on the bulletin boards for all to read. A month later, get teams of students to make a survey to determine whether these safety rules are being practised. If not, what can be done about the matter?

Major Concept 2. What is known about first aid has to be practised at all times.

Concept 2-a (p. 41): Snake bite venom travels with blood circulation and acts rapidly on the heart.

1. Learn to recognize poisonous snakes in your locality. Study their habits and characteristics. Study figures IV. 8, 9 and 10. Discuss what you observe.

2. If you go on field trips, carry an anti-venom kit with you. It will contain a tourniquet, a razor blade, antiseptic, a knife and a suction cup.

3. If you were faced with an accident, what would you do? Suppose you were on a field trip to gather science specimens and one of the party was bitten by a snake. Would you do these things? Keep the person quiet. (Why?) Open the wound made by the fangs with a sterile knife (use a flame suction cup and to sterilize it) or a razor blade. If you have no suction cup and no open sores in your mouth, try sucking some of the poison out. Keep this up for about 15 minutes. Get the bitten person to a doctor as fast as possible.

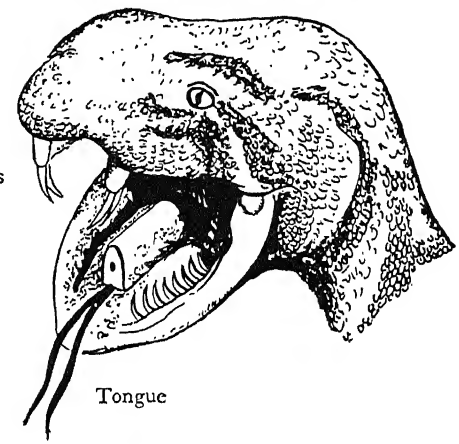
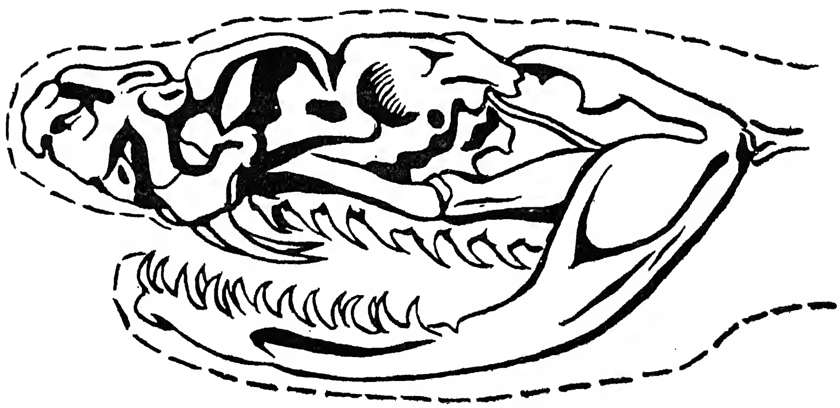


Fig. IV.8. Head of a cobra.

Try to identify the snake if possible, as this aids

Fig. IV.9. Skull of a poisonous snake.



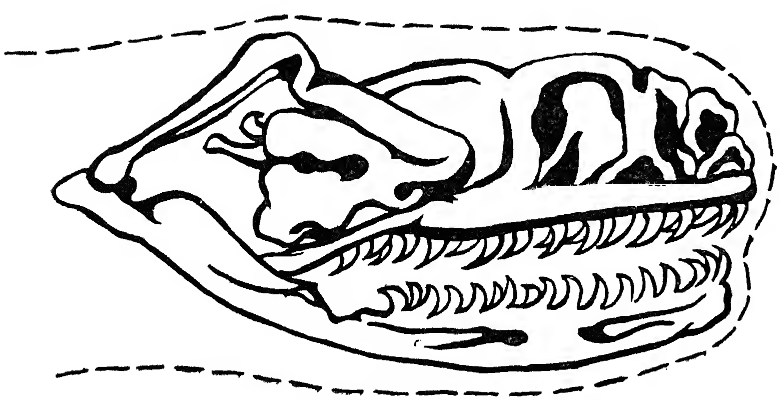


Fig. IV.10. Skull of a non-poisonous snake.

the doctor in the treatment, that is, in determining the anti-venom to administer.

4. Find out about anti-venoms and report to your class.

Concept 2-b,c (p.41): (b) A ligature will prevent blood from going towards the heart.
(c) A fractured bone requires support and rigidity by splints.

1. Refer to illustrations in and study for bandaging wounds and applying tourniquets. Always tie the tourniquet between the wound and the body.

Obtain class VI an Indian Red Cross Mannal or a Scout First Aid Book.

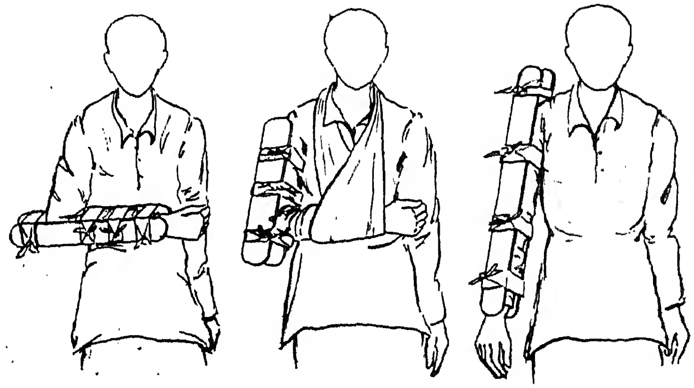


Fig. IV.11. Splints.

2. Practise bandaging imaginary wounds, making slings and splints, and note the procedures to follow for different injuries. Remember First Aid is what is done *only* until the doctor arrives.

3. Get a doctor, nurse, or scout leader to talk and demonstrate to your group.

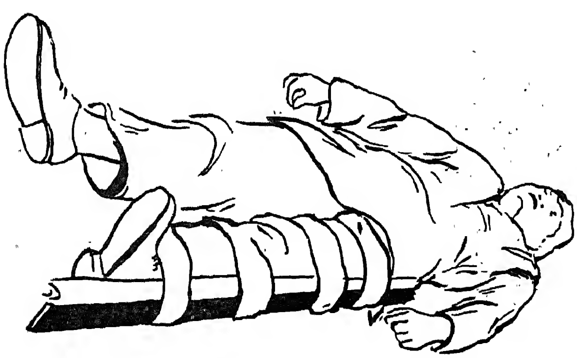


Fig. IV.12. Fixed traction splint.

4. Suppose you are with a person who breaks a bone or tears a ligament. What do you know? What should you do? Usually a broken bone will cause swelling. It usually looks deformed and different from the corresponding limb which is uninjured. You as a first-aider should do the following.

(*a*) Make the person comfortable, but move him very little as a simple break or fracture may become a compound one if handled carelessly.

(*b*) Call or send for a doctor.

(*c*) If no doctor can come and the person must be moved, a 'fixed traction' splint should be applied. However, a temporary splint may be made with materials at hand. A leg splint can be made of a long wooden board cushioned with a roll of clothing and held in place with strips of cloth knotted outside the wood.

Likewise a splint for the lower arm can be made of rolled newspaper and held in place with strips of cloth. Never move a person with a fracture without a splint.

(*d*) A person with a fractured collar bone

usually cannot raise his arm above the shoulder. You can feel the broken ends by moving your fingers over his collar bone.

Put the arm on the injured side in a sling and bandage it tightly to his body. Leave the ends of his fingers uncovered, so that you can check on his circulation.

(*e*) Fractured ribs cause pain when a person coughs or takes a deep breath. If he is not bleeding, place two or three broad bandages about his chest and back to limit chest motion. If bleeding, keep him lying down at a level for ease of breathing, and keep him warm. Get medical aid.

(*f*) If a person cannot move his legs, his back may be broken. Do not move him except to roll him on his back, until a doctor comes. If he has to be moved, tie him on to a rigid board or stretcher with coats and sweaters packed about his head and shoulders. Immobility is essential.

Major Concept 1. Setting an example by practising safety precautions is an important duty of every good citizen.

Concept 1-a **(p. 41)****:** In any emergency, bleeding should be first attended to.

You have seen accidents and observed how people crowd about the injured one, usually with no idea of how to give first aid. Often injured people are in a place where medical aid is not available.

1. A good first aider will size up the situation. He will gather a rough idea of the nature and extent of the injury.

2. A good first aider will know what to do first.

3. Is there bleeding ? This should be stopped. If it is not severe, treat as suggested in activities given under concept 2-b for class VI.

If the bleeding is from an artery (that is, coming in spurts corresponding to heart-beat) recall where the pressure points in the body are. (Fig. IV. 13). Application of pressure at the pressure point between the heart and the wound may stop bleeding. Delay the use of a tourniquet for it can be dangerous, as it may cut off circulation and destroy tissues.

Fig. IV.13. Pressure points indicated by arrows are the same on both sides of the body.

Concept 1-b **(p. 41)****:** Artificial respiration can restore respiration in many cases when it is failing.

Most people think that artificial respiration applies only to drowning persons. At what other time might respiration stop and some artificial aids be necessary? Any time one stops breathing or when oxygen is shut off from the blood. Have you witnessed such a situation ? What did you do ?

1. Did you call for a doctor? Suppose it takes sometime for the doctor to arrive? Can you assume some leadership in first aid?

2. Why will air pressure save lives? If a person is not breathing, you can press down on the back of a person. What are you doing? You are pressing or squeezing his lungs. Explain in your own words what you have done. It may go something like this: 'When I stopped squeezing the lungs, air from outside rushed in to fill the lungs which were not now squeezed, but of normal size.' By repeating this squeeze and release, an artificial breathing cycle is set up which will sustain his life until his own mechanism of breathing starts again.

A plan of artificial respiration has been used for sometime. There are several methods. Find out about them. Why is one better than another? Practise one or more methods, so that you can meet an emergency.

(a) In the back pressure-arm lift method (also known as the Holger Neillson method), the person is placed face down, head on bent arms with face to one side.

(1) Operator kneels at the head of the victim and facing him, places his hands on the flat of the person's back so that the heels of his hands lie just below the lower tip of the shoulder blades.

arms upward and towards you. As you rock back, do not bend your elbows.

The arm-lift expands the chest by pulling on the chest muscles, arching the back and relieving the weight on the victim's chest. Drop the victim's arms gently. You are ready to start the cycle again. It should be done 10 to 12 times a minute at a steady uniform rate. If you tire, coach another to take your place without any change in the rhythm. The rule is keep on at artificial respiration for at least 4 hours unless the patient revives and begins to breathe normally before that time.

(b) The mouth to mouth method is gaining favour all over the world. Learn this method and practise it. This method is easy to perform, provides oxygen quickly and can be used even with a chest injury. Here is a description of the method. Learn it and demonstrate it to others.

(1) Place the victim on his back (face up). In this position, you can best care for his respiration. Do not put anything under his head, as it may flex the neck causing the air passages to be blocked.

(2) Quickly clear his mouth of any foreign matter by running your fingers behind his lower teeth and over the back of his tongue. Wipe out any fluid, vomitus or mucous. This cleaning should not take more than a second or two since little time should be lost in getting air into the victim's lungs.

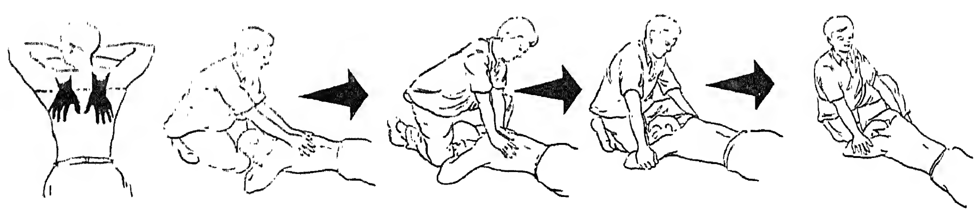


Fig. IV.14. Artificial respiration; back pressure-arm lift method.

The thumbs just touch each other while the fingers are spread down and out.

Rock forward allowing the weight of your body to exert slow downward pressure forcing air out of the victim's lungs. Keep your elbows straight.

(2) Release pressure. Place hands on the victim's arms just above his elbows and draw his

(3) If available (do not waste time looking for these materials), place a rolled blanket or some other similar material under the shoulders so that the head will drop backward. Tilt his head back so that the neck is stretched and the head is in the 'chin-up' position. This keeps the air passages from becoming blocked.

(4) Place your thumb in the corner of his

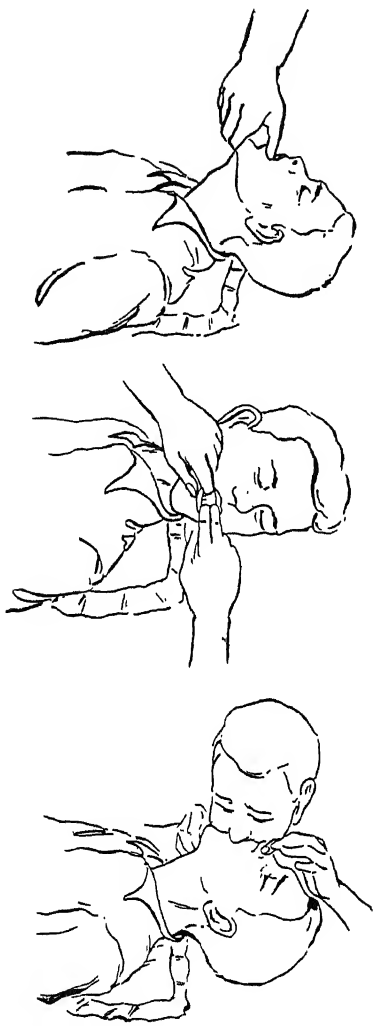


Fig. IV.15. Artificial respiration—mouth to mouth method.

mouth and grasp the lower jaw firmly. Lift the lower jaw forward to pull the tongue forward out of the air passage. Do not attempt to hold or depress the tongue.

(5) With the other hand, pinch the nose shut in order to prevent air leakage.

(6) Take a deep breath and open your mouth wide. Seal your mouth around the victim's mouth and your thumb, and blow forcefully (except for infants and small children) into his mouth until you see his chest rise. (If the chest does not rise, hold the jaw up more forcefully and blow harder while making sure there is no blockade of the air passage and no air leakage around the mouth or nose.)

(7) When his chest rises, stop blowing and quickly remove your mouth from his. Take another deep breath while listening for his exhalation. (If his exhalation is noisy, elevate the jaw further.)

(8) When exhalation is finished, blow in the next deep breath. The first five to ten breaths must be deep(except for infants and small children) and given at a rapid rate in order to provide rapid reoxygenation. Thereafter, continue breathing at a rate of 12 to 20 times a minute with only moderate increase in normal volume. In this way, rescue breathing can be continued for long periods without fatigue.

(9) After performing rescue breathing for a period of time, you may notice that the victim's stomach is bulging. This bulging is due to air being blown into the stomach instead of the lungs. Although an inflation of the stomach is not dangerous, it makes inflation of the lungs more difficult. Therefore, when you see the stomach bulging to a marked degree, apply gentle pressure to the stomach with your hand, between inflations.

(10) Remember: Keep the air passages as clear of fluid and other obstructions as possible; keep the head back, the neck stretched, and the chin pulled forward; readjust your position if you are not able to breathe forcibly enough or if too large a volume is going in, or if the casualty is an infant or small child. In infants, seal both the mouth and nose with your mouth and blow with small puffs of air from the cheeks, rather than from the lungs. If you become distressed as a result of the shallow breaths, interrupt the blowing long enough to take a deep breath, then resume blowing.

Major Concept 2. Providing leadership by teaching others what is known about accidents, their prevention and first aid treatment is a contribution to the community welfare.

Concept 2-a,b,c,d (p. 41) : (a) Sharp objects should not be left lying about.
(b) Children should be kept away from high voltage electrical installations by means of fences.
(c) Traffic laws must be obeyed.
(d) Poisonous drugs must be kept away from the reach of children.

Do you consider yourself a leader in helping to prevent accidents ? Are you constantly improving your knowledge of first aid ?

1. Would you know what to do in case of heat stroke ? Heat exhaustion results from excessive loss of water and salt from the body. Dizziness and faintness are symptoms.

In very hot surroundings, there may be a stoppage of sweating. The victim may have a bright pink colour and may become delirious. It is imperative that the body temperature be lowered at once, by immersing the body in cold water or cold water with ice. If a cold bath is not available, get the victim in the shade, remove clothing and pour water over him. Cool by continuous fanning. Get medical aid, but keep up the cooling process during transport. Give him cool salt water to drink as soon as he is conscious.

2. What would you do if you saw someone suffering from electrical shock ?

Why would you never touch the victim directly ? If a person has come in contact with an electric current, turn off the switch if it is nearby, but do not waste time looking for it. Use a dry wooden pole, dry clothing, dry rope or some other material which will not conduct electricity to remove the person from the wire. If a pole is not handy, simply drag the victim off the wire by means of a loop of dry cloth. Do not touch the wire or the victim with your bare hands. Electric shock causes breathing to cease, so start artificial respiration immediately after freeing him from the wire.

3. List the common injuries which occur in your life, and work out a plan of action for each possible emergency. Suggestions are : What to do in the case of a foreign body in an eye? What to do in the case of food or chemical poisoning ? What to do in the case of carbon monoxide poisoning ? How to handle a person having an epileptic fit ?

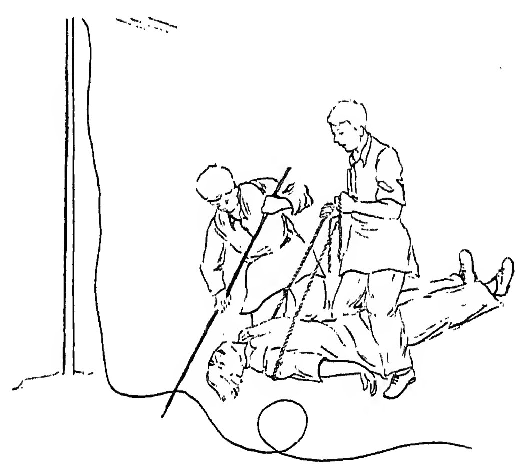


Fig. IV.16. Freeing victim from live wire.

4. Obtain and tabulate the common causes of accidents in your school. Are these kinds of accidents common in other parts of the country? What is being done in your school to reduce accidents ? Keep a graph of accidents and their reduction on your school bulletin board.

5. What is the sickness percentage for your school ? Tabulate the common causes of illness in your group. Urge other classes to do this. Are they alike in causes ? What measures should be started to control absences from classes for certain illness ? Make a graph of present illnesses and repeat this after some control measures have been instituted.

UNIT V HOUSING & CLOTHING

CLASS VI

Major Concept 1. A building site should be carefully selected for healthy living.

Concept 1-a (p. 45): Houses should be so planned as to permit maximum light during the day.

If you live in the country you may have plenty of natural light entering your house, provided the windows are well located. In city apartments very few rooms are lighted well by natural light.

1. Observe how your school and home are lighted. On which side or sides are the windows? Are they on the south, north, east or west? What should determine their location? (In the far north, the hours of sunlight should be considered.) In your schoolroom, does the light come from the back or from your left? Does it ever come from directly in front of you?

2. In house-planning, an area of approximately one-fourth to one-fifth of the floor space should be given to windows, and a house should be so placed that the rooms which are lived in most, and those who sleep inside, should get some direct sunlight each day. Discuss the reasons for such a plan. (With modern air conditioning, the proportion of window area is reduced.)

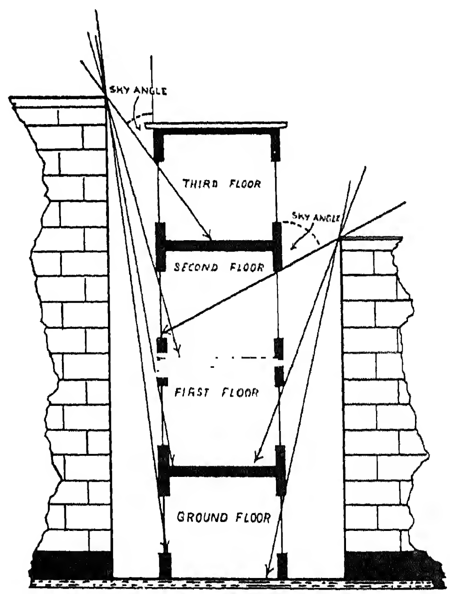


Fig. V.1. An apartment house.

Concept 1-b (p. 45): A house should not be built on a low site.

Notice what happens to the low spots on the school playground after a heavy rain. Are these places still damp when other places have dried up?

Discuss how a low site might get refuse and seepage from higher places.

Concept 1-c (p. 45) : The neighbourhood should not obstruct air and light from entering the house.

1. Study the apartment house diagram Fig. V.1. Discuss these statements.

(*a*) In buildings on narrow streets, the angle at which the light strikes the windows is an important consideration.

(*b*) It has been found that only 10% of sky light passes through a window if the light strikes it at an angle of 10 degrees, while 90% of the light goes through if it strikes at an angle of 90 degrees. Draw some angles and observe the light as it enters your house windows.

(*c*) The colour of nearby buildings is an important factor in lighting. If a nearby building is of red brick or dark stone, will it reflect little or much light? What about a white building? Test this by using your eyes on a piece of black paper and a piece of white paper in direct sunlight. Inside the house, the colour of the wall is related to light distribution. White walls reflect 76% of the light, brown only 22%, and olive green only 14%.

(*d*) The Venetian or porch blind helps to cut off the glare of the sun's rays, but does not prevent circulation of air.

2. Discuss whether principles about light and housing apply equally well in the tropics and farther north. Will sun breakers be necessary in the tropics for protection from direct glare? Are large verandahs still practical in the face of large population? Are apartment houses suitable in the tropics?

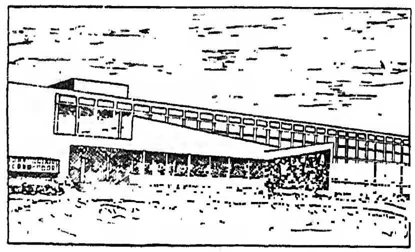


Fig. V.2. Sun breakers on South side of a government building in Chandigarh.

Concept 1-d (p. 45) : A good house should be located, if possible, near routes of communication.

1. Obtain some material from the Department of Tourism in India or write to the Chamber of Commerce in Chandigarh. Study the sector plan in the city of Chandigarh. Each sector you will find is $\frac{1}{2}$ mile $\times$ $\frac{3}{4}$ mile so that an inhabitant at the farthest corner is at easy walking distance from the centre to places that cater to his daily needs. Discuss the advantages of such a plan. Could modifications of such a plan be made even in older towns and cities ?

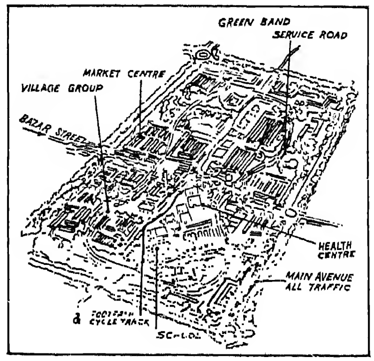


Fig. V.3. Lay-out plan of sector 22, Chandigarh.

Major Concept 2. A good house should have proper ventilation, light, sanitation and water supply.

Concept 2-a (p.45): The house should have adequate water supply free from pollution.

1. Find out where your water comes from. Is it from your own well? From a town or village well? Is it a deep well or a surface well? Does your well have a concrete lining? Does it travel from a source far up in the mountains through pipes to storage reservoirs, and thence by pipes to your home? Perhaps it is stored in a big reservoir so that it flows under pressure,

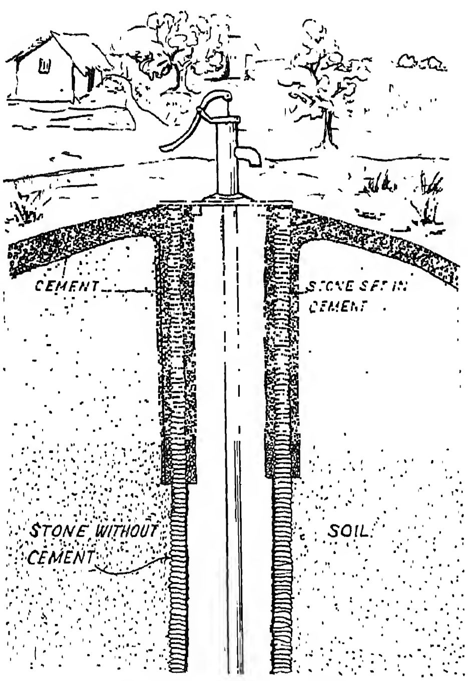


Fig. V.4. Sanitary well.

downhill to your home. Do you know why a reservoir is placed on a hill ? Make a sketch showing what route the water you drink takes from its source until it reaches your home.

Some people in the world drink rain water as they have no other source. If rain water is collected in cisterns, it is probably pure.

2. Is your drinking water pure? Do you boil the water you use? Is the source of your water checked regularly to guard against infection? Make a list of diseases that may be caused by drinking impure water, such as, typhoid fever, dysentery, cholera, paratyphoid, etc.

3. Write your answer to this question: What is pure water? Have you included these characteristics?

a. Water that is clear.
b. Water that is colourless.
c. Water that is tasteful.
d. Water that is odourless.
e. Water that is free from harmful germs.
f. Water that is free from decaying organic matter.

Now find out how each of these is accomplished.

a. Shake muddy water in a jug. Let it

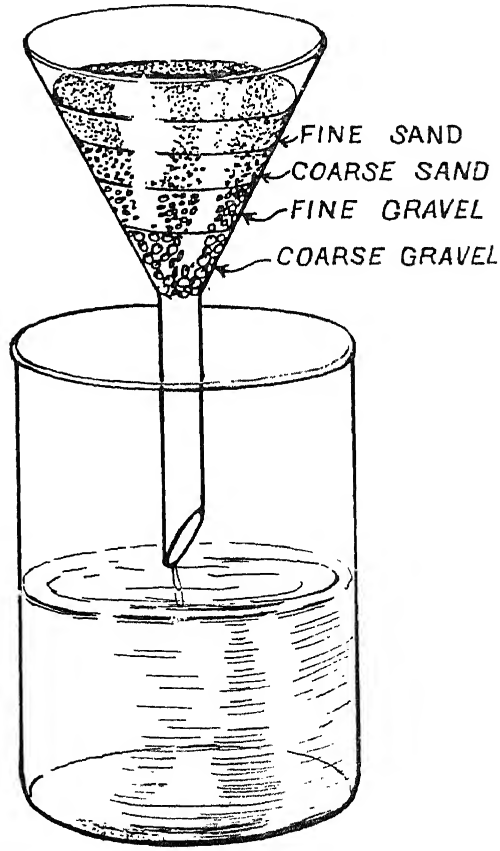


Fig. V.5. Model of a water filter.

settle. Is it pure? Add a pinch of alum. Does it settle faster? Is it pure?

b. Filter some water. Follow the model in Fig. V. 5.

c. Boil some water for 20 minutes. Taste it. You dislike it. Let it stand in the air or pour it from one clean container to another. Now taste it. Most odours are gone. It is probably pure after boiling.

d. Find out if chlorine is used in your water supply. Chlorine is poisonous, and so very little is used, but it is effective in killing disease germs. In small quantities it is not harmful to human beings.

e. Add a drop of potassium permanganate solution to a test tube or bottle of dirty water. Notice that the colour changes quickly from pink to brown, showing the presence of organic matter. Test clean water also.

4. Obtain a film or filmstrip on 'How to Keep Water Pure'.

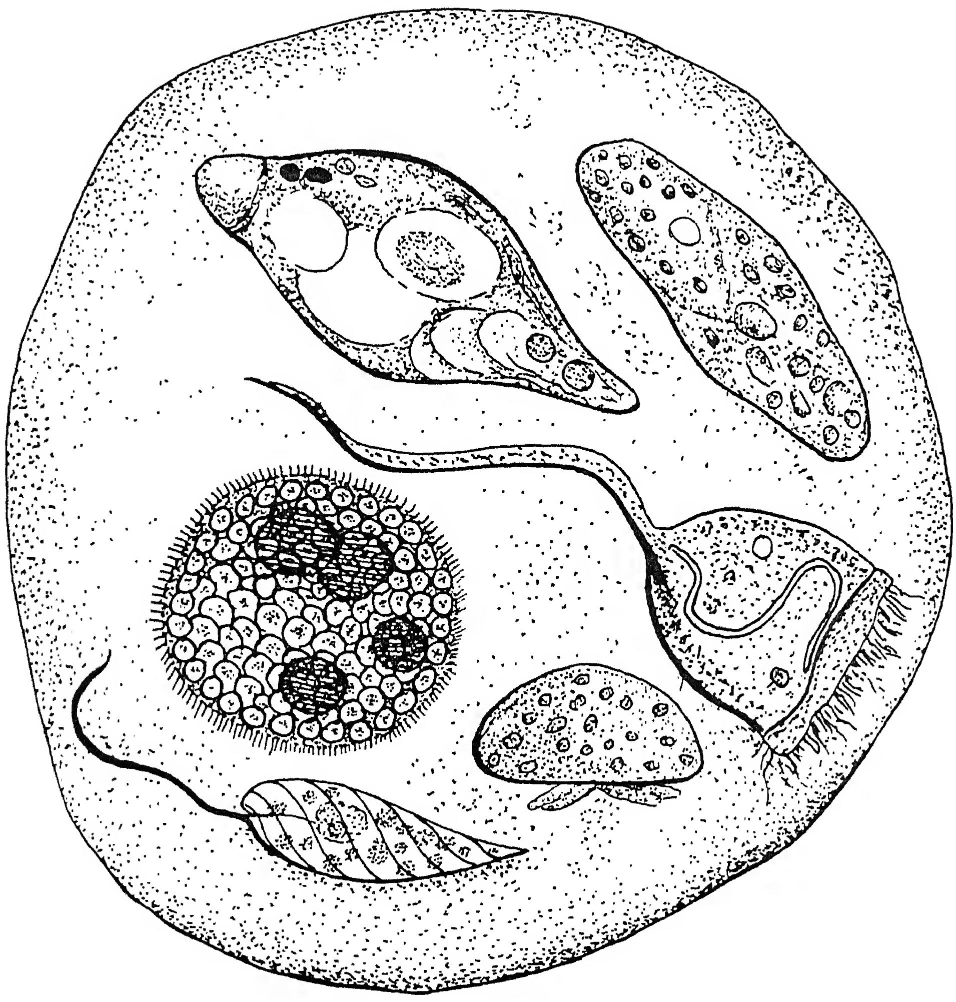


Fig. V.6. Stagnant water containing microscopic living things (magnified).

Concept 2-b (p. 45): There should be proper arrangements in the house for drainage of water and removal of other refuse.

1. Find out how the water is drained from your house. Where does it go? Do you have

plumbing in your house, i.e., are pipes used for carrying in and distributing water, and are pipes used for taking out waste material? In order to get water and wastes out of the house, a system of drain pipes is necessary. A vent pipe extends from the first floor to the roof to carry off odours and gases produced by wastes. Why must drain pipes leave the house at the lowest level? Are there any traps to collect waste and grease below your kitchen and bathroom sinks? An inverted siphon is used in the trap. How does it work?

2. Construct a siphon. Take a rubber or plastic tube or a bent tube of glass having unequal arms. It will serve to transfer a liquid over an elevation from one vessel to another at a lower level.

Air pressure on water in the two vessels holds water up in the siphon. The weight of water in the left hand column is balanced by the weight of water in the right column marked a - b. The weight of water in the right hand column marked b-c makes the water flow from the higher level to the lower level. Likewise, in the waste trap, the weight of water in the right hand limb makes water flow out of the trap. But when air enters the trap, the siphon effect stops and some water is left to seal off the sewer pipe.

a. Fill the tube full of water. Close its openings with your fingers.

b. Place the shorter tube in liquid at higher level.

c. When your fingers are removed, how long will the liquid continue to flow? (As long as the end of the shorter arm of the siphon is covered by the liquid and the levels of the liquid are unequal.) The siphon uses a very useful principle. What effect does the pressure of the atmosphere have on the flow? Why did you fill the tube with water first?

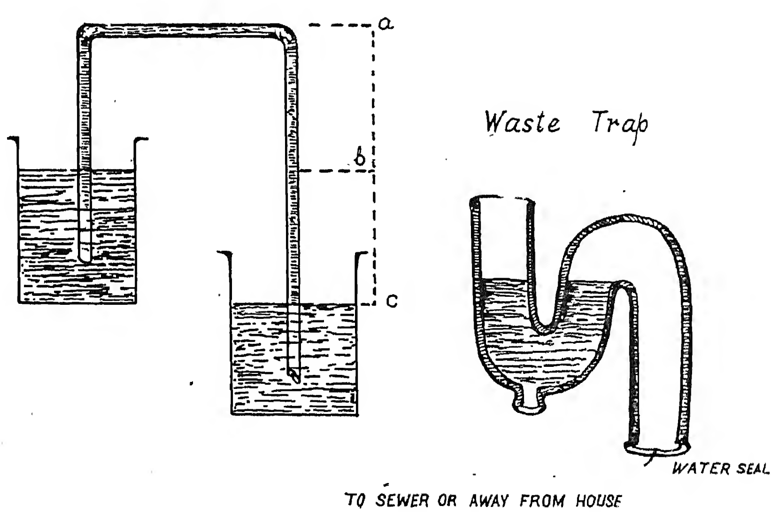


Fig. V.7 a-b. Model siphon and inverted siphon of a waste trap.

3. Relate what you know about the siphon to the inverted siphon in the waste trap. Note the water seal. Water standing in the trap (siphon) seals it against returning odours. By using such a device, odours and gases from waste do not get into the house. Find the siphon in your flush tank. Do you live in the country or in the city?

4. How are garbage and other refuses taken care of? Are they buried, burnt, or fed to animals? Visit a garbage dump and observe the number of flies present. Make a chart of diseases that may be carried by flies. Let a fly walk across a prepared dish containing a culture medium for growth of bacteria. Leave the dish in a warm dark place for a couple of days. Do you see little coloured spots forming on the culture medium?

How many can you count? Each spot is a colony usually started by one micro-organism. Disease-causing micro-organisms are carried by flies. Garbage should not be allowed to stand uncovered because flies will breed in it.

Fig. V.8. Collecting bacteria in the air.

Concept 2 c, d (p. 45-46) (c) Location of latrines and urinals needs careful selection in relation to the house and the neighbourhood, and the drinking water supply.
(d) Latrines and urinals should be kept clean and disinfected.

Study Figs. V. 10 a, b on page 126.

1. Do you know of any situations akin to Fig. V. 10 a in your neighbourhood? Where is your latrine in relation to your water supply? Is there any drainage of barnyard or house waste into your well? Is there a tight cover on your well?

2. Both places in the illustration have epidemics of typhoid fever. Why? What remedy do you suggest?

3. Is your house latrine or toilet fly proof?

4. Conduct a campaign against flies. Make a series of posters showing in a vivid way why flies should not be allowed to breed. Plan a 'Rid-of-the-Fly' campaign.

5. Devise a fly trap. Provide some bait or lure. See illustration, Fig. V.9.

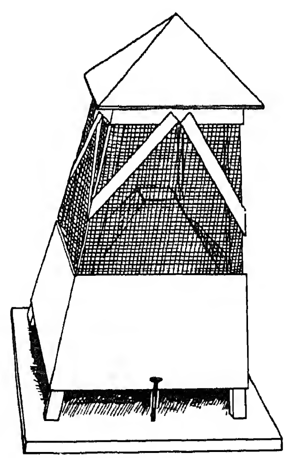


Fig. V.9. A fly trap.

Find out about cess pools, septic tanks, and sewers or drains. Find out if any large cities in India have sewage disposal plants to take care of wastes in a scientifically safe way.

Fig. V.10 a. Common (country) water supply dangers.

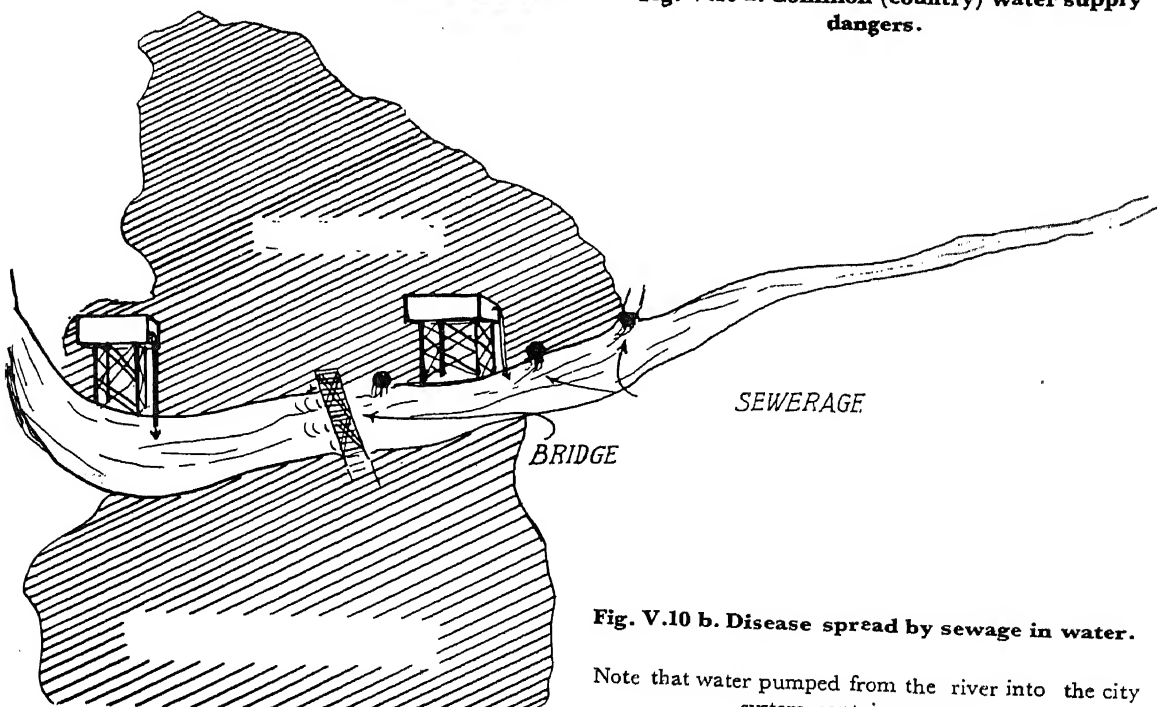


Fig. V.10 b. Disease spread by sewage in water.

Note that water pumped from the river into the city system contains sewage.

6. Find out if quick lime, chloride of lime or creosote are kept in your out-door toilet and used, especially after any infection of any member of the family with dysentery, diarrhoea, or cholera.

Concept 2-e (p. 46): There must be proper ventilation to permit maximum movement of fresh air.

1. Hold a burning punk stick or incense stick near the bottom of a window and then near the top. Draw with arrows the circulation of air, cold air moving in from outside and warm air moving out from inside. Is such circulation of air necessary even in winter? Explain why.

2. Show how Venetian or porch blinds can cut off the direct glare of the summer sun without preventing the circulation of air.

Concept 2-f (p. 46): Ample sunlight should be available within the house and the courtyard.

Discuss the statement: 'Sunlight is a good germicide.' If you believe in this statement, how will this influence you in trying to keep some sunlight in your house and yard? Is it possible to have too much shade?

Concept 2-g (p. 46): The plinth of the house should be well above the street level.

Because of the great strength of concrete, it makes an excellent plinth for a house or building. Such plinths prolong the life of a house by assuring uniform distribution of the weight of the house on the soil.

Why should the plinth be built on firm soil?

Why should the plinth level be above the street level?

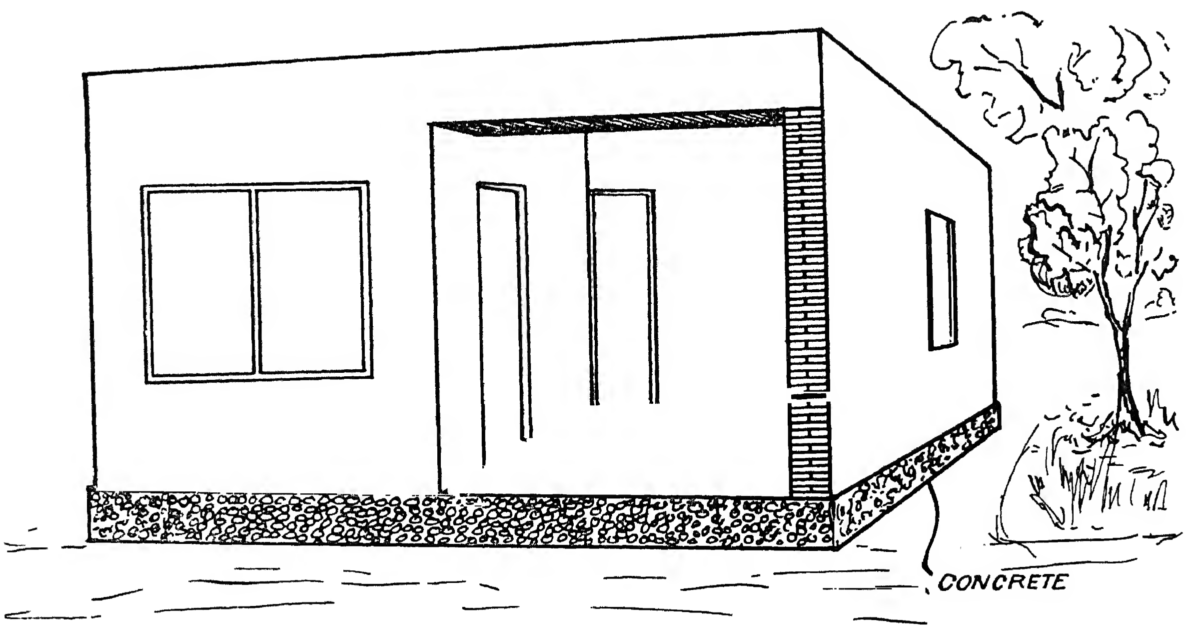


Fig. V. 11. House built on concrete plinth.

In cold places, why should the plinth be below the level of frost penetration?

Discuss the phrase 'a place to live in' as contrasted to a 'shelter'. Write some points you would consider if you were building a house. After studying about this, see if your ideas are the same, somewhat modified, or totally changed.

Major Concept 1. Brick and tile are made of clay.

Concept 1-a,b (p. 46): (a) Clay is put in moulds and dried to make brick and tile.
(b) Brick and tile are burnt in kilns to make them stronger and more resistant to water.

1. If possible, visit a place where bricks and tiles are made. Is a dry or wet method used? Observe the kiln.

2. Recall what you have found about the weathering of rocks. Clay is sediment formed by the break-up of slate and shales. Make two wooden moulds. Get some clay and make two model bricks in the moulds. Bake one in an oven or kiln if possible. Take both bricks and soak them for a day in the same amount of water. Weigh both. Does your kiln-burnt brick absorb more or less water ?

3. Make small bricks of plaster of Paris, house mortar, and cement in the wooden moulds. When they are thoroughly dry, test them in equal amounts of water. Which absorbs the most water during the first quarter of an hour? Which absorbs least during a long soaking of a day? How do they compare with the clay bricks you made? Make a chart to show your findings.

	15 min.	1 hr.	1 day
Baked Clay			
Plaster of Paris			
Dried Clay			
Mortar			

4. Read the history of brick making. It dates back to earliest civilizations, it is said, perhaps 12,000 years ago. Bricks have been found in excavations showing the way people lived 6,000 years ago.

Major Concept 2. From limestone are made cement, concrete, mortar and white-wash.

Concept 2-a,b (p. 46): (a) Cement is made by heating limestone and clay in a special furnace called 'kiln.'
(b) Concrete is made by mixing cement, sand, gravel and water in the right proportions.

1. From your study of rocks and minerals, recall that limestone is one of our basic sediments, made up largely from the pulverized shells (calcium carbonate) of creatures of the sea. From time to time, parts of the sea-bed rose above the water and became dry land. Limestone appeared above the water as soft rock. Check a piece of limestone with your hardness test. Try carving

a piece of limestone with your pen knife. Drop some acetic acid (vinegar) on a piece of limestone. If it 'sizzles', it is limestone. The acid brings bubbles of gas out of the solid rock. Limestone is a very useful substance. Make a chart of its different forms and uses.

2. Get a little cement from a builder. Make a mould as in Fig. V.12 so that you can make some test pieces of cement mixtures. Mix cement in different proportions with sand. Mould test pieces of each mixture. Allow them to set for a week, then test their strengths. Make one test piece by reinforcing it with wire. Test it and compare it with the others.

TABLE V.1.—SOME MATERIALS FROM WHICH CALCIUM CARBONATE IS OBTAINED, AND THEIR USES.

Uses	Material	
	ROCKS	
	↓	
1. Carving 2. Improving soil 3. Smelting 4. Statues	Chalk Limestone Marble	(With clay and sand makes cement.)
	↓ Heat	
	Quicklime	(carbon dioxide is given off.)
	Add a little water.	
1. Making mortar 2. Improving soil.	Slaked lime	(Heat is produced.)
	↓ Add more water	
1. Loosening hair from animal skins before tanning. 2. Pumping skins or diaphragms.	Milk of lime	
1. Test for carbon dioxide. 2. Making babies food digestible.	Lime water	

SOME FORMS OF CALCIUM CARBONATE

Chalk	Snail shell
Marble	Egg shell
Coral	'Fur' in kettles
Seashell	'Scale' in water pipes.

Stalactites and stalagmites (in caves)

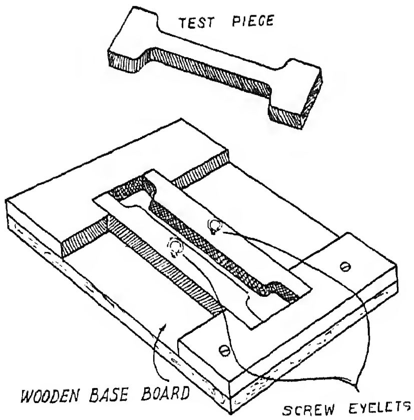


Fig. V.12. Mould for cement mixture.

3. To test the bending strength of a test-piece of cement, clamp one end to a bench and suspend an improvised scale pan from the other with a strong cord sling. Put rocks or weights (if available) in the scale pan until the test-piece breaks. The area of a cross-section of the narrow of the test sample should be $\frac{1}{4}'' \times \frac{1}{4}''$, or 1/16 sq. inch. Test and compare samples of concrete which have set for 2 days, 5 days and one week. Which is strongest ?

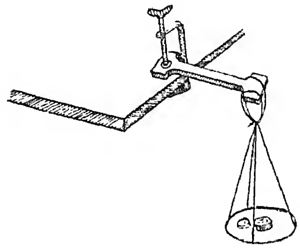


Fig. V.13. Testing the strength of cement.

4. Find out how the Egyptians used lime and gypsum mortar to cement together great stones, and how the Romans discovered a good cement made from lime and volcanic ash.

5. Find out about Portland cement, of which lime and sand are the main ingredients, but which goes through about 80 operations in its manufacture. It has been used all over the world since its discovery in 1824.

Concept 2-c, d (p. 46) : (c) Quick lime is obtained by heating limestone in kilns.
(d) Slaked lime is obtained by adding a limited amount of water to quick lime.

Heat a piece of limestone to make a new substance, quick lime (or lime). When it is cold, drop a little water on it. Feel it. It is warm. You have made slaked lime, and in the process heat was produced.

Concept 2-e (p. 46) : Mortar can be made by mixing slaked lime, sand and water in the right proportions. A better kind of mortar is made by mixing cement, quick lime, sand and water in the right proportions.

Plan a demonstration to show both ways of making mortar. Think of a way to test which is better for building.

A. Mortar = slaked lime + sand + water.

B. Mortar = cement + quick lime + sand + water.

Concept 2-f (p. 46) : White-wash is made by adding water to slaked lime.

Have you ever rubbed against a room wall when wearing a dark coat or chemise? What happens? You have rubbed off some of the white-wash made from water and slaked lime, used for painting walls and cement blocks. White-wash gives a clean appearance to a room even after much use.

Major Concept 3. Building materials have different properties.

Put up on your table or bulletin board the skeleton of a house, such as walls, doors, windows, and roof. Then as materials are selected, put samples or drawings on your skeleton house. Perhaps as reasons for selecting a material are given, you may have a roof of three possible materials because all three come up to the standards you have set. Keep on 'building' your model house as various building materials are studied.

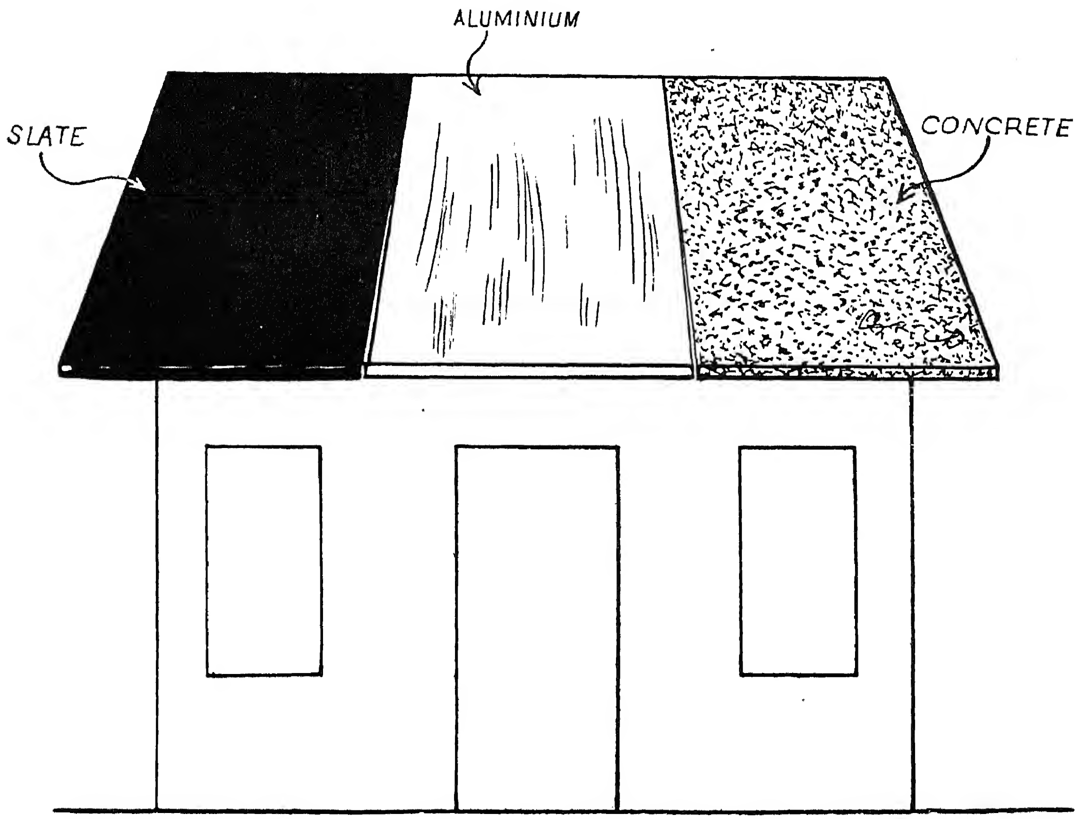


Fig. V.14. Experiment with roofing materials.

Concept 3-a (p. 46): Brick and concrete are hard and rigid. They can be given any desired shape.

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1. You have found by your earlier tests of concrete that particular combinations are stronger than others. Research scientists are still learning about such things.

Have you seen a curved concrete roof? Do you think it possible to build one? They are being used for aeroplane hangars, gymnasiums, and some schools. Places that need much clear, high-ceilinged floor space may use curved roofs, either barrel-shaped or dome-shaped.

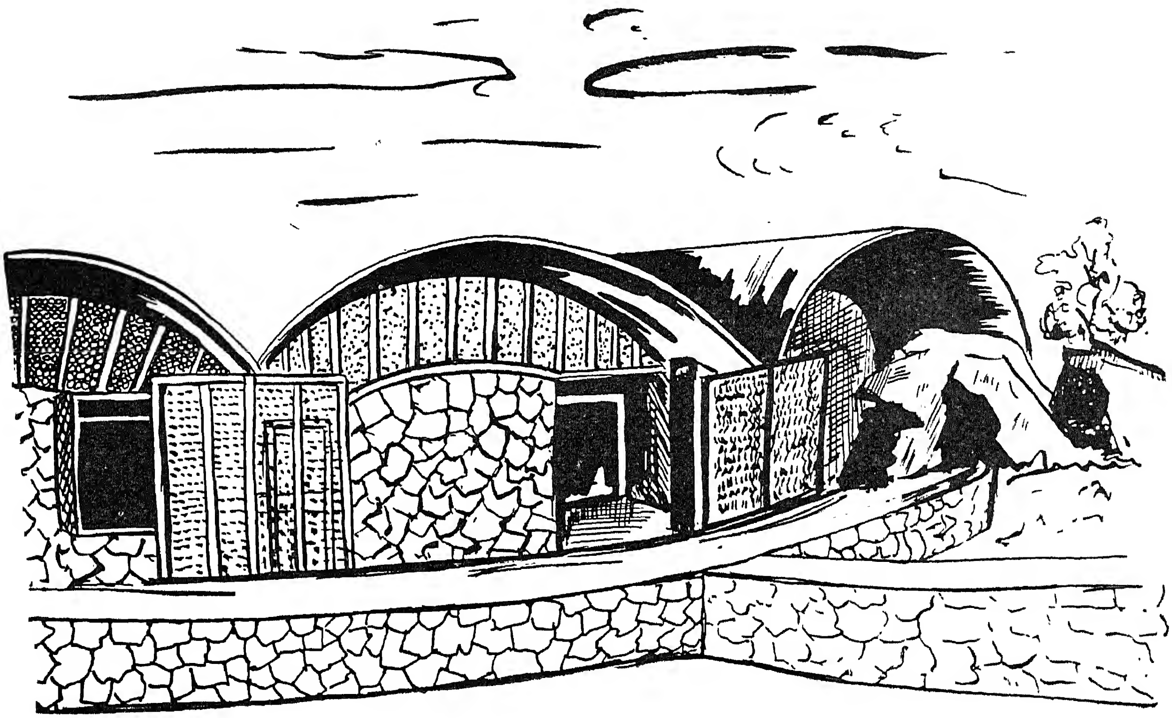


Fig. V.15. A curved roof.

2. Make a test to see if you can determine whether a shell-like structure such as this is exceptionally strong. Try breaking an egg or bending a table tennis ball, not by pressing at one or two points but by wrapping your hand completely about it and pressing equally in all directions. To be successful, you will have to exert great force.

3. Bend a playing card to a dome and see how many coins it can support. What have you done? The weight tending to bend the arch is counterbalanced by the force of the support that maintains the arch. A roof such as the curved dome behaves in a like manner. Explain this.

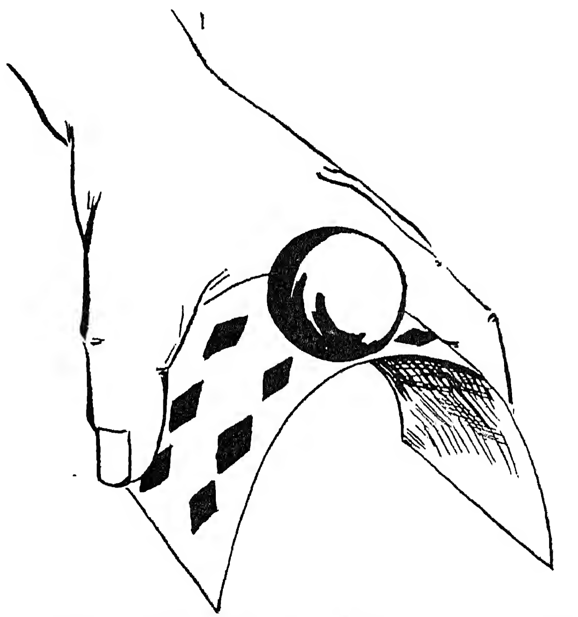


Fig. V.16. A bent playing card supports weight.

Concept 3-b,c (p. 46): (b) Concrete reinforced with a matrix of iron bars bears greater stress than regular concrete.
(c) Mortar sets into a hard layer on drying. It is used for making surfaces smooth and waterproof.

Find out about reinforced concrete. Get some information from a builder on the increased carrying capacity of reinforced concrete. If you live near a city, observe the construction of multi-storeyed

buildings. Is there a bridge or dam which you can watch being constructed? Is the concrete reinforced? How?

Review the results of your tests of with reinforced concrete compared to the other samples.

Concept 3-d (p. 47): Cement-asbestos sheets are light, fire-proof and good insulators. They are used for roofing, siding and panelling.

Get a piece of flexible asbestos. Sometimes asbestos is used around stove pipes. Test asbestos by trying to burn it. What do you find? (It is fire-proof.) If you can get a piece large enough to wrap tightly about a drinking glass, test another characteristic of asbestos. Take two glasses; put cold water in each. Wrap one glass tightly with asbestos. Take the temperature of each. Set them aside. Take the temperature regularly every 15 minutes. Which one stays cold longer? You will find asbestos is a poor conductor of heat, and so it is a good insulator.

Concept 3-e (p. 47): Aluminium and galvanized iron sheets are light and fire-proof. They are used for roofing, siding and panelling.

1. Observe and make a list of materials you see used for siding and roofing of houses.

2. Can you think of any reason why aluminium would be used for roofing and siding?

Take a sheet of aluminium foil and a sheet of black paper. Place both in the sun at the same angle. Do they feel about the same temperature at the time you place them? Feel them at 15-minute intervals. Does the aluminium foil remain cooler? Account for this. Is aluminium a poor conductor of heat?

3. Place two cans, one painted with dull black enamel and the other left shiny, in the sun. Add to each an equal amount of cold water. Cover the open top except for the place where you put a thermometer. Take the temperature of each at 15-minute intervals. Which warms up faster? What quality, do you conclude, has the shiny can?

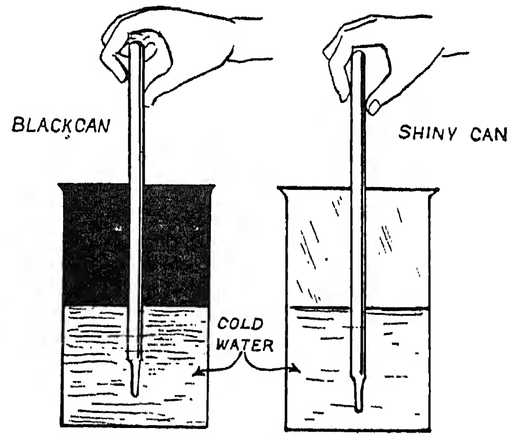


Fig. V.17. Experiment with dull and shiny surfaces.

Is this similar to that of bright aluminium? If you put aluminium on your roof, what might you expect of it, besides shelter from the rain? (inculcating effect, reflects sun's rays.)

Concept 3-f (p. 47): Iron is used as a frame in large buildings.

1. Report on the manufacture of steel from iron. What is the basic process?

2. Observe the steel frame of a building under construction. Does it remind you of the bony skeleton of a human body? Think what tremendous weight these steel girders must support in the brick, stone, mortar, metal, glass, concrete, and wood of various parts.

Concept 3-g (p. 47): Wood is light, easily shaped and a good insulator. It is used for support for roof and in making doors and windows.

1. Compare equal portions of wood, concrete, and iron. Can you carve iron? Can you carve concrete easily? What about wood? Discuss why wood is used in houses where light weight, easily moulded material is needed.

2. Wood is burnable, but heat does not pass through it easily. Hold an iron nail and a similar sized piece of wood in a flame. Which of your fingers is heated up first? (The one holding the iron nail.) When heat travels fast through a material, we say it is conducted fast, that is, it moves rapidly from molecule to molecule. Such material, we say, is a good conductor of heat. Would a good conductor of heat be a poor or good insulator? In general, would wood rather than metal be a better insulator?

Concept 3-h (p. 47): Glass and plastics admit light, are good insulators and are waterproof. They are used for doors and windows.

1. On a hot day compare the metal frame of a car with the glass in the windows. Is the glass as hot? Have you observed places where glass is used to lessen the passage of heat?

2. Read about the new uses of glass and plastic, such as hollow glass and plastic blocks, which serve as panels and blocks, admit light, keep the place private, and are decorative also. Plastic blocks look like glass blocks but are only one-fifth the weight. These are being used for outside walls and partition walls between rooms.

Find out about fibre glass.

Major Concept 4. Houses need periodic repair, white-washing and painting.

Concept 4-a (p. 47): White-washing and painting keep the walls dry and attractive. Plastic paints are more durable than white-wash.

Paint two similar boards, one with white-wash and one with plastic paint. Leave them out in the weather. Observe the durability of each over a period of months.

Concept 4-b (p. 47): Paints and varnishes make woodwork attractive and protect it from moisture and termites.

Paint a board similar to that in 4-a, with varnish. Observe how it looks after a severe rain storm.

Concept 4-c (p. 47): Iron fixtures are painted to prevent rusting.

Take three iron nails. Paint one with finger nail polish (plastic paint); paint one with grease and leave one unpainted. Place them in a damp place. Why should iron be painted or treated chemically before use in building? Recall from previous experiments on rusting that iron and oxygen combine readily.

UNIT VI Energy and Work

CLASS VI

ENERGY

Major Concept 1. Energy is the ability to do work. It is of two kinds, potential and kinetic.

Concept 1-a, b **(p. 52)****:** (a) Potential energy is stored energy.
(b) Kinetic energy is energy of motion.

1. To show potential energy:
   (*a*) Observe a ripe mango falling spontaneously on soft earth.
   (*b*) Throw a ball high up and observe how it ultimately falls down. What energy causes its downward movement?

2. Show how a book on a table falls to the floor when pushed over the edge of the table. It possesses energy due to gravity, gained by being lifted to the height of the table. This energy is potential energy. It will be converted to kinetic energy whenever the book is pushed over the edge of the table. Likewise, rocks on top of a hill possess potential energy.

3. To enable pupils to understand the idea of 'work', discuss their experiences of cases where any object has been moved over some distances, vertically, horizontally or in any other direction by muscular power, machines, springs, fireworks, running water or a moving object. In all such cases 'work' has been done when force has been applied and object has been moved. The force comes through 'energy'. To show that energy has no weight, weigh a flask containing hot water and reweigh it again after it has cooled.

4. Weigh a wound spring and reweigh it after unwinding and note the difference, if any. How is the potential energy of a wound spring different from that of a book on a table?

5. To show that kinetic energy is energy of motion, suspend an ordinary balance as is used by the shopkeeper and drop on one pan small beads, one by one, at first slowly and then with greater force. Is the movement of the balance affected by the speed of the bead? How?

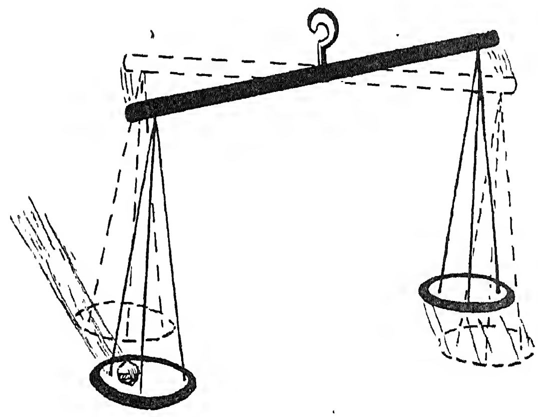


Fig. VI.1. Kinetic energy is energy of motion.

Also note how the kinetic energy of a hammer, for example, is used to do work. Try pushing a nail into a piece of wood. Then try driving it in with a ruler. Next try driving it in with a hammer. Why does the nail move into the wood when you hit it hard with a hammer? Kinetic energy is energy of motion. Give other examples of the use of kinetic energy to move things.

Major Concept 2. Potential energy has many forms.

Concept 2-a (p. 53): Water stored at a height is an example.

To show that the weight of water may be made to do work, construct a water wheel with buckets so that one side of the wheel becomes loaded with water as shown in the figure. The weight of the water turns the wheel. The potential energy of the water gets converted into the kinetic energy of the moving wheel.

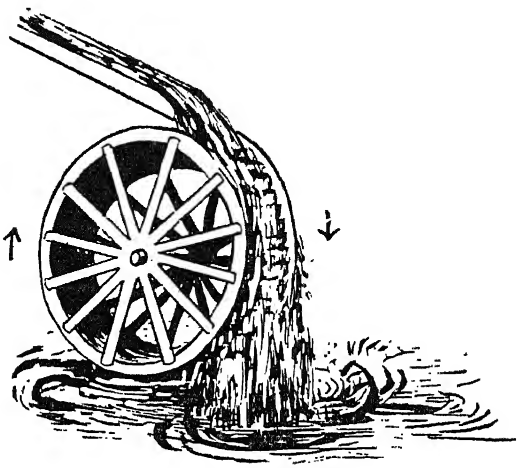


Fig. VI.2. An overshot water-wheel.

Concept 2-b (p. 53): Energy stored in a bent bow or a wound spring is another example.

Demonstrate the stored energy in a bow when it is bent to shoot an arrow. Use a spring to show stored energy.

Concept 2-c (p. 53): Chemical energy stored in food, in fuels or in a storage battery is also potential energy.

Soak a small piece of cloth in methylated spirit and apply a burning match stick to it. What energy is given off when the cloth burns? Similarly how is heat obtained from the burning of coal, firewood or charcoal? Why does a brick or stone not burn and give energy? What kind of energy is stored in fuels?

Press the switch on a torchlight and observe the bulb glowing. From where does the bulb get the energy? Why can the bulb not get energy indefinitely from the cells?

Concept 2-d (p. 53): Electrostatic energy of charges in a cloud is an example of potential energy.

Prepare a paper electroscope. Cut a strip of paper 60 cm long and 10 cm wide. Fold it in the centre and hang it over a ruler as shown in the Figure VI-3 (*a*). Stroke the paper several times with a piece of woollen cloth (*b*). Bring a plastic comb rubbed with flannel between the two folds of paper (*c*). Observe how the paper leaves diverge. What has caused them to do this? Discharge the electroscope by bringing your fingers between the folds (*d*). What do

you observe? Now bring a glass cup rubbed with a piece of silk below the paper leaves (*e*). What happens to them?

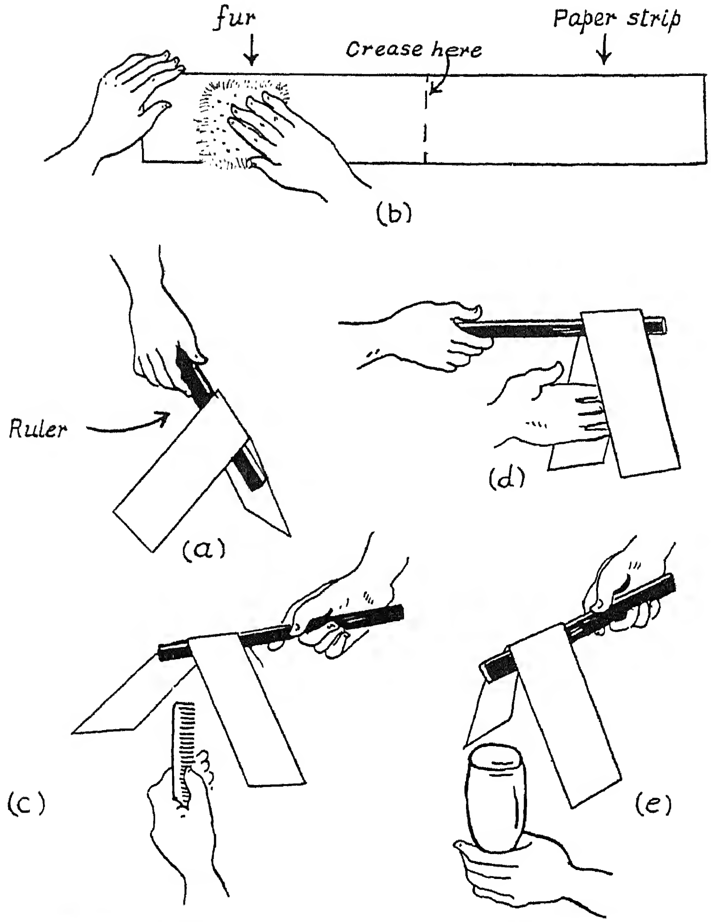


Fig. VI.3. Paper electroscope.

Concept 2-e (p. 53): The latent heat of steam released as the steam condenses illustrates potential energy.

Fill about a third of two large beakers of the same size with equal amounts of cold water. Note the temperature in both. Then pass steam through a jet into the first beaker from a boiler for a few minutes until the water attains a temperature of 90°C. Note the beaker again to find the volume of steam passed.

Now take the other beaker and add boiling water to it till the temperature is the same as in the first beaker. Note the volume of boiling water required to raise the temperature to 90° C. Compare this volume with that from the condensed steam.

Which volume is greater (boiling water or steam)? What does it indicate regarding the quantity of heat released by steam compared with that of the same weight of boiling water?

Relate this idea with the absorption of heat when water boils or ice melts and the severity of steam burns as compared to scalding by hot water.

Concept 2-f (p. 53): Atomic energy, that is energy stored in the atom, is potential energy.

Get a radium dial watch. Darken the room and observe the light of the figures on the dial.

Major Concept 3. Kinetic energy has many forms. Examples are given in 3a to g.

Concept 3-a (p. 53): Energy of a falling body.

1. Cut slots into the sides perpendicular to the ends of a cotton reel or a wide cork. Insert pieces of tin or wood as shown in the figure. Use a knitting needle or a thin pencil as an axle. Support the axle on a pair of grooved wooden stands. Upon completion of your model, direct a stream of water from a tap or guided from a tank and observe the vanes moving by the kinetic energy of the water. Relate this to the idea of utilizing water power from dams on rivers.

2. Let a ball fall from the top of a table to the floor on which a lump of wet clay or plaster is kept. How is the clay or plaster splashed up?

3. To feel the momentum of a falling body, toss a heavy ball high in the air and then catch it. Notice how the hands are pushed towards the earth by the momentum of the ball.

Compare the momentum of the ball when it falls five metres, with its momentum when it falls ten metres. Compare the momentum of a stone which weighs about a kilogramme with that of a stone which weighs half that, when each of them falls through the same distance. Feel the difference as you catch the falling stones.

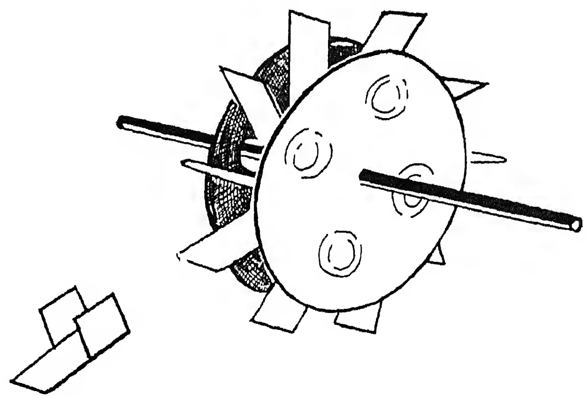


Fig. VI.4. Model of a water turbine.

Concept 3-b (p. 53): Energy of a moving body like the automobile.

Recall and discuss instances in which moving vehicles out of control have smashed or destroyed objects in their path. Compare the energy of a moving loaded truck with that of a small car.

Concept 3-c (p. 53): Energy of an arrow in flight.

Hang a piece of paper like a curtain. Pierce it with a shot from a toy gun or an arrow from a bow.

Compare the distance that a rapidly flying arrow will penetrate an object, like a tree, with that of a slowly moving arrow. Upon what factors does the momentum of an arrow depend? (Upon its mass and its speed.)

Concept 3-d (p. 53): Heat energy, that is, the motion of molecules.

Carefully warm a balloon filled with air and tied up over a candle flame or near a fire. Observe that it expands and then bursts due to the more violent bombardment of the air molecules moving much faster within the balloon.

To see the effect of heat energy on the motion of molecules, take two candles and light one. Hold a thin strip of paper above each of the candles

in turn. Observe the effect of heat on the air around each candle. How has the heat affected the air around the lighted candle? Can you explain this in terms of the motion of air molecules?

Concept 3-e (p. 53): Light energy, that is, electromagnetic waves.

To show that light energy—electromagnetic waves—is a form of kinetic energy, compare the temperature on a hot summer day under a shady tree with that in the bright sunlight. Also compare the temperature at noon time with that at night. What effect has sunlight on the temperature of the air? Give at least one reason why it is warmer in the day time than at night, in summer than in winter.

Concept 3-f (p. 53): Sound energy—vibrations in air.

Pour a little water in a shallow metal dish. Strike the edge of the vessel lightly with a wooden stick, and notice the sound produced. Observe also the movement or vibration of the metal and water as sound is produced.

Strike a tuning fork or pluck the string of a violin or a *sitar* and observe how they vibrate as they produce sound. The vibrations of a bell can be felt by touching the other lightly with the finger. Hold one end of a ruler tightly at the edge of a table with your thumb or with a vice and pull the other end down then let it loose (*a*). Observe the vibrations as sound is produced. As the ruler bends upwards, it compresses the particles of air above it (*b*). As the ruler springs back, it causes the particles of air above to separate (*c*). When the ruler springs back up, it will again compress some air above it. Thus as the ruler springs up and down, it alternately compresses and thins out the air.

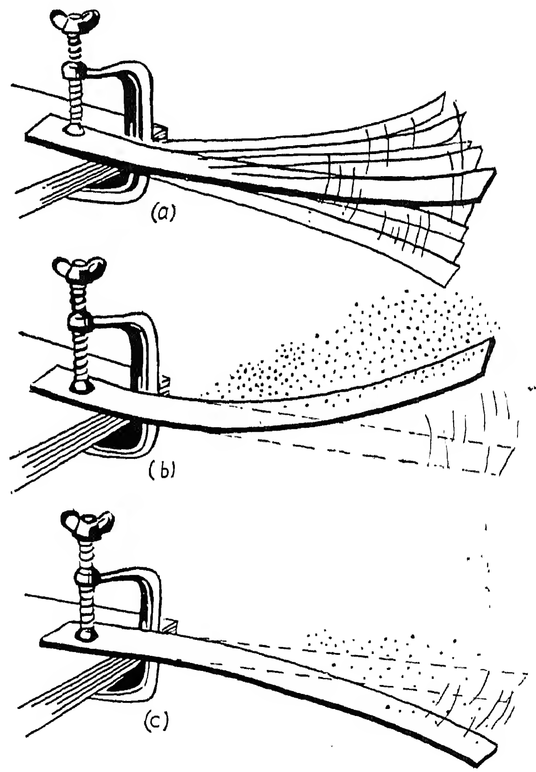


Fig. VI.5. Vibrations of sound shown by the movement of a ruler.

To show that sound energy is something vibrating, feel the motion of a drum, as it is beaten, or of a violin as its strings are bowed, or of your larynx as you shout. In all these cases note that whenever there is sound, something moves. Hence sound is a form of kinetic energy.

Concept 3-g (p. 53): Electrical energy—the energy of an electrical current or a stroke of lightning.

Connect an ordinary voltaic cell (Refer to VI-6, concept 4-c) to a door bell and close a switch to set it ringing. What makes the hammer move to and fro?

Relate this to various electric motors used in everyday life, where electricity is made to work or move things.

Recall the many forms of energy that are readily produced from electricity: heat, light, mechanical motion, sound, etc. Recall that a stroke of lightning which is an electric current and flowing between clouds produces sound, light and heat. The heating of the air through which the lightning passes causes thunder. When the lightning flashes, the potential energy—electrostatic charge in the cloud—is changed into kinetic energy.

Major Concept 4. Each form of energy is either kinetic or potential or both.

Concept 4-a (p. 53): When a boy moves downwards on a see-saw or a swing, his potential energy becomes kinetic energy; as he moves up, his kinetic energy becomes potential energy. At any one time he possesses some of both kinds of energy.

To make pupils understand that each form of energy is either kinetic or potential or both, discuss the following in the light of the activities done earlier.

1. Kinetic and potential energy of a boy on a sea-saw or a swing.
2. Movement of water in a dam through the penstock and turbine.

Concept 4-b (p. 53): As water is forced through a penstock, its potential energy becomes kinetic energy.

To verify that the water flowing in a hose has both potential and kinetic energy, fix a nozzle to a hose and show that water may be squirted much further than when allowed to flow freely. When the end of the hose is constricted, the potential energy due to the pressure of the water is increased at the nozzle end. This energy is converted to kinetic energy in the nozzle. A small amount of water is made to move farther and faster than the large amount of water which flows when there is no nozzle. Compare the potential energy with the kinetic energy present in the hose in both situations.

Concept 4-c (p. 53): As a storage battery is charged, the kinetic energy of electric current becomes potential chemical energy; as it discharges, the potential chemical energy of the battery becomes kinetic electrical energy.

To show the energy changes that occur when a storage cell charges and discharges, make a simple storage cell, charge it, and then use it to light a torchlight bulb or to ring a bell. Take a wide-mouthed jar and fill it three-fourths with a dilute solution of sulphuric acid. (Prepare by adding one part concentrated sulphuric acid to two parts water. *Caution*: Add acid to the water, slowly, while stirring vigorously. Never add water to the acid).

Take two lead plates each about 2 cm wide and 10 cm long. Connect wires to each. Place the

ends of the lead strips in the dilute acid, and charge the cell by connecting the wires to a storage battery. Notice that as the cell is charged, one of the plates becomes red. The lead has been changed to lead peroxide on this plate. Then disconnect the storage battery and connect the wires from the cell to the torchlight bulb. The bulb should light up. What energy was put into the cell? What energy was stored in the cell? What energy came out of the cell? What energy came from the light bulb? Which of these forms were kinetic? Which of these were potential?

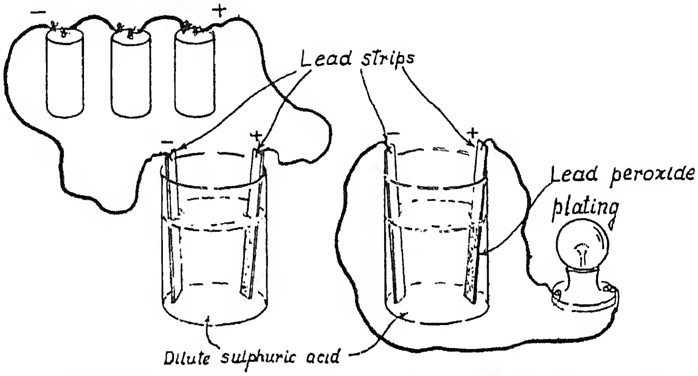


Fig. VI.6. Energy changes in a storage battery.

Major Concept 5. The different forms of energy are interchangeable.

Concept 5-a (p. 53): Chemical energy is changed into heat energy when substances burn.

Burn a candle, a kerosene lamp or solid fuel to see how it changes while burning and how it yields heat and light. What other forms of energy also change into heat energy?

Concept 5-b (p. 54): Heat energy is changed into mechanical energy in various kinds of engines.

Show a model steam engine or an internal combustion engine in which heat is converted into mechanical energy. What kind of energy is present in the steam or in the burning gas? How does this energy move the engine parts?

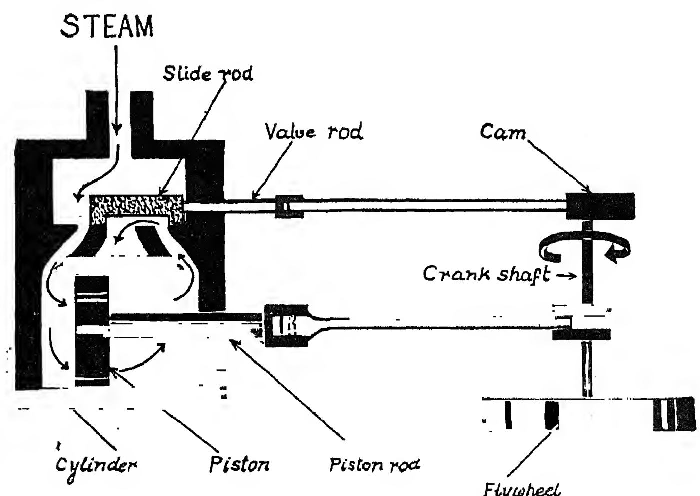


Fig. VI.7. Working diagram of a steam engine.

Concept 5-c (p. 54): Light energy is changed into chemical energy in the green leaves of plants.

Take a potted plant and cover a portion of one or two leaves on both sides by pinning a black paper or tin foil (Fig. VI.8a) on it early in the morning before sunrise. Keep the plant in the sun for six hours.

Now, pluck the leaf, remove the black paper, and warm the leaf in alcohol to remove the chlorophyll. Apply starch-iodine test to find out where starch is present in the leaf. Which part of the leaf did not receive light? In which part was starch not stored? Account for your results.

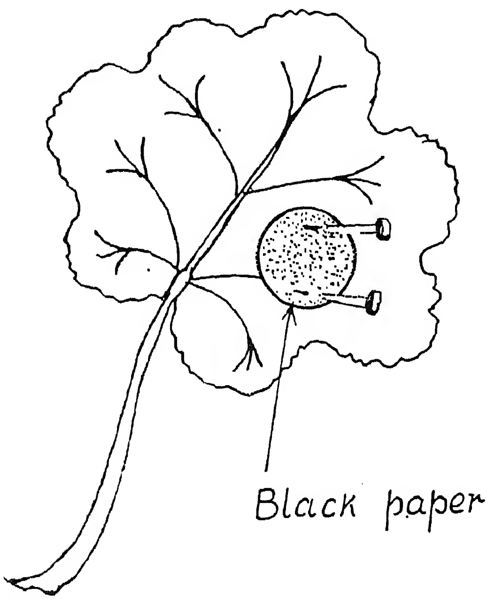


Fig. VI.8a. Change of light energy to chemical energy in the green leaf of the plant.

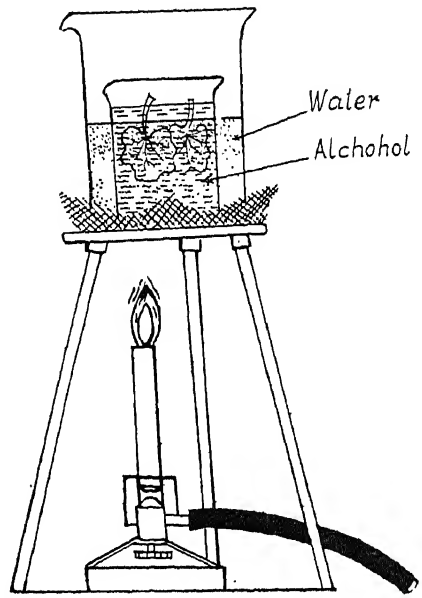


Fig. VI.8b. Safe heating of leaves in alcohol using water bath.

Concept 5-d (p. 54): Mechanical energy, heat energy, atomic energy and light energy may be changed into electrical energy.

To demonstrate that mechanical energy may be converted into electrical energy, turn a magneto and demonstrate that it produces electrical energy. You may show this by connecting its terminals to a torchlight bulb. Is current produced when there is motion? Is it produced when there is no motion? Does the magneto turn faster when a bulb is connected in the circuit? What energy is converted into electrical energy in the magneto?

If a magneto is not readily available, see if you can show the class a motor cycle or a scooter, and demonstrate how as the engine turns, a spark is produced. This could be brought out vividly by disconnecting the wire from the spark plug. Arrange a thermocouple as shown in Fig. VI.9.

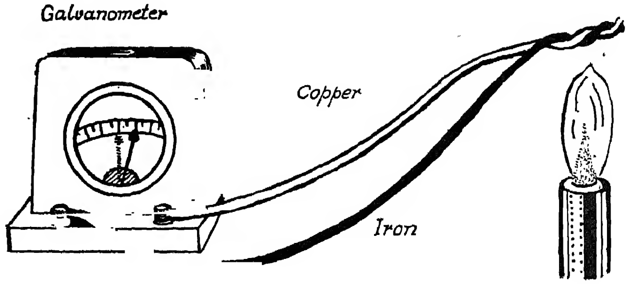


Fig. VI.9. Model of a thermocouple.

Take a piece of copper wire and another piece of iron wire (each about 25 cm. long). Twist together one end of the copper wire with one end of the iron wire. Connect the other ends of the wires to a galvanometer. Now heat the twisted ends of the wires in a flame. The needle will deflect showing the presence of an electric current. What energy is converted into electrical energy?

The energy of atomic fuels may be converted into heat energy. Perhaps you can also find out how this is done. Arrange a class discussion on how it works. In what ways may heat energy be converted into electrical energy?

The light meter (or exposure meter used for photography graphs) contains a photo-electric cell. This is made up of light sensitive material which generates a small electric current when light falls on it. The current passes through an ammeter and is indicated by the movement of its hand across the dial. Demonstrate with a light meter that light energy may be changed into electrical energy.

Some photo-electric cells act as a switch. This can be shown by connecting the terminals of a photo-electric cell to a galvanometer and throwing a beam of light on it.

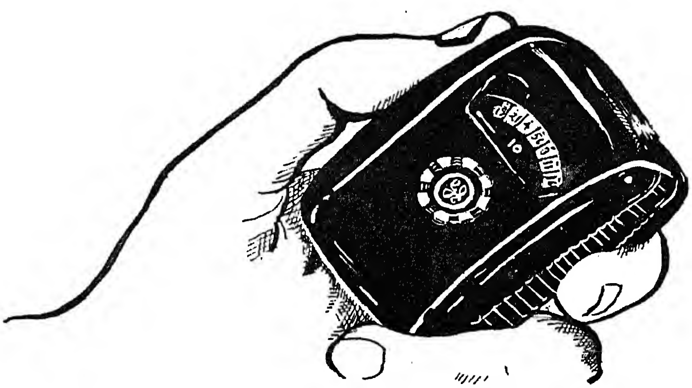


Fig. VI.10. Light meter (exposure meter) used to measure intensity of light.

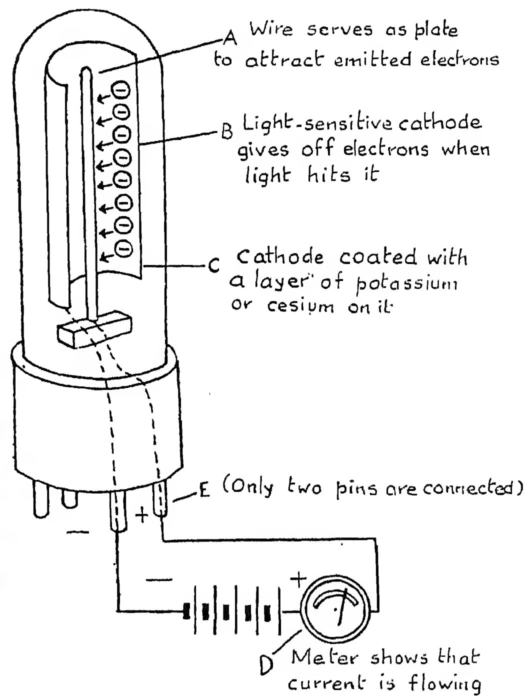


Fig. VI.11. A photoelectric cell.

Concept 5-e (p. 54): Electrical energy may be conveniently converted into light, heat, sound and mechanical energy.

Discuss that electric bulb, heater, iron, etc., are devices that convert electrical energy into light and heat in daily life. The electric fan is a good example of conversion of electricity to mechanical energy. The loud-speaker and telephone receiver are illustrations of the conversion of electricity into sound waves. (The microphone and telephone transmitter are illustrations of the conversion of sound waves into electrica energy.)

Major Concept 6. Various forms of energy are used by man for getting work done.

Concept 6-a (p. 54): Man harnesses the potential energy of water at a height, and of fuels to produce electrical power to turn the wheels of industry and for domestic purposes.

To show how a piston steam engine works, study the diagram under Fig. VI-7. How is the piston moved back and forth? What drives it? From where does the steam get its energy?

Concept 6-b (p. 54): Man produces huge quantities of standardized items with a minimum of human labour, as for example, cloth, screws, bolts, autoparts, radios, etc.

Discuss how various objects in your school were produced. Were machines used? What forms of energy were probably used. If possible, take your class to visit a factory which uses machines to mass-produce its products. Discuss how energy is harnessed and used by these machines.

Major Concept 7. Various forms of energy have replaced human-energy or animal-energy in making travel and transport quicker, easier and more comfortable.

Concept 7-a, b (p. 54): (a) Automobiles are replacing bicycles and carts in travel.
(b) Steam, petrol and electric engines are used in transport.

1. Take the pupils on field trips or excursions to places like railway station, factory, electric power house, water supply station, automobile repairing shop, or road building spots where machinery is being used.
2. To find how a bicycle works, bring one into the classroom and study its operation. Put it upside down on its handle bars and saddle. Turn the pedal arm once around and see how many times the rear wheel turns. Calculate how far the bicycle travels for each revolution of the sprocket wheel.

Concept 7-c (p. 54): Turbines and motors are used to propel ships.

List, identify, and classify according to type of engine used, the various kinds of engines used in transport. Perhaps you can find out how one or more of the engines work. If so, have a class discussion of the findings.

Concept 7-d (p. 54): Better highways are constructed using power driven machinery, to make travel faster, safer and more comfortable.

Compare the construction of trunk highways with that of secondary roads. What are the characteristics of the trunk highway, that make possible a rapid flow of heavy traffic? Consider the surface, smoothness, road-bed, grades, curves, bridges, roadside drainage, centre lanes, traffic circles, cross roads, limited access, and use of traffic control systems such as signal light.

HEAT

Major Concept 1. Heat is a form of energy.

Concept 1-a (p. 54): Heat is the motion of particles (molecules) of a substance.

To develop the mental image that heat is motion (molecular motion), have students speculate regarding the nature of heat. What is it that happens when an object is heated?

Concept 1-b (p. 54): When a substance is hot, its molecules are moving rapidly; when it is cold, its molecules are moving less rapidly

Major Concept 2. Heat produces many effects on bodies.

Concept 2-a (p. 54): Heat raises the hotness (temperature) of bodies.

That heat raises the temperature or hotness of bodies is a common experience for children. The idea however should be developed that cooling really means withdrawal of heat from a body.

Concept 2-b (p. 55): Heat expands bodies.

Heat expands bodies—solids, liquids and gases.

1. Secure two different-sized screw eyes (as are used for hanging photographs). One should just pass through the other. Screw each one into the head of a stick as shown in the figure. Heat the head of the smaller screw eye in a flame and then try to pass it through the larger one. Keep the first screw eye hot and heat the larger one in the flame at the same time. Now try to pass the smaller through the larger. Keep the larger one in the flame and cool the smaller one by plunging it into cold water. Again try to pass the smaller through the larger. Next cool the larger one. Will the smaller one pass through now? What have you learnt about expansion of solids caused by heat?

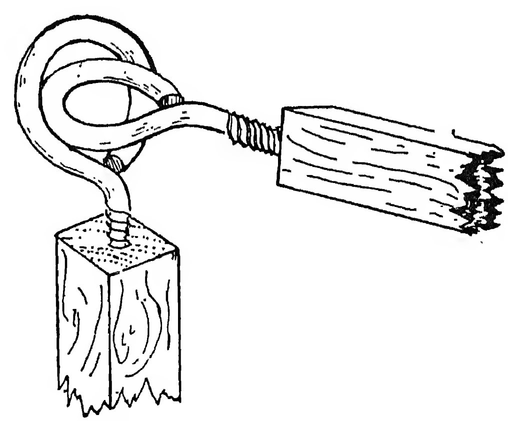


Fig. VI.12. Expansion of solids by heat.

2. Fit two or three similar medicine bottles with corks and tubes of the same size as shown in Fig. VI.13a. Fill them with different liquids. Keep the bottles in a pan of water and warm the pan. Observe the liquids rise in the tubes. What is the difference in the levels to which the liquids in the glass tubes rise? How do you account for this difference? Observe if the same difference obtains when you allow the pan to cool.

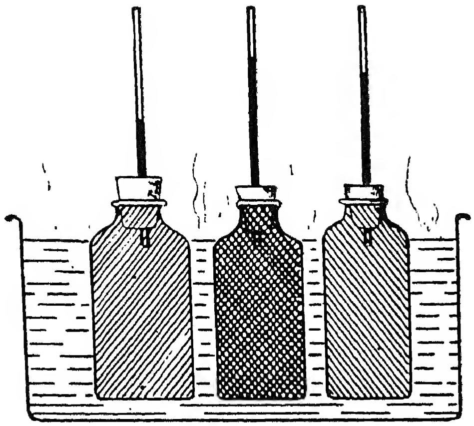


Fig. VI.13a. Expansion of liquids by heat.

3. In the tube of a medicine bottle fitted with a long glass tube, trap a bubble of water. Fit the cork on tightly. Warm the bottle with the palms of your hand. Notice that the bubble moves up. Why? It will be more distinct if the bubble is coloured with ink. See Fig. VI. 13b.

Let the bottle cool and then observe the movement of the bubble.

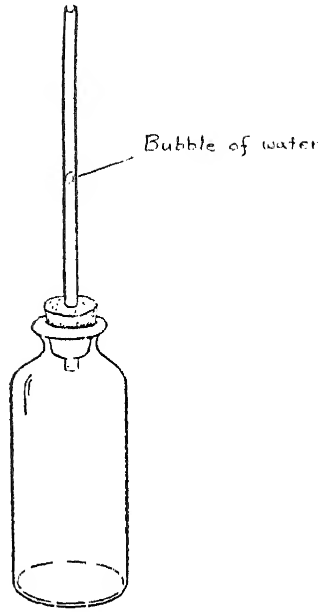


Fig. VI.13b. Expansion of gas by heat.

Fit a balloon on the neck of a heat-proof flask, Heat gently. What happens to the balloon? Explain why.

Concept 2-c (p. 55): Heat brings about a change in the physical states of substances.

To show that heat changes the state of bodies, heat a little wax, butter and sugar separately in shallow dishes. Keep spirit in another shallow dish away from the flame. Observe what happens to each. What makes the spirit disappear?

Recall experiences, if any, of distillation of water where conversion from liquid to vapour and *vice versa* has taken place.

Concept 2-d (p. 55): Heat brings about chemical changes.

1. Burn pieces of magnesium ribbon, cotton thread, and paper separately and examine. Is the residue in each case similar to the starting substance?

2. Heat strongly a little mercuric oxide or lead oxide along with a little powdered charcoal. Examine the substance left in the test tube and compare with the original material you started with.

Major Concept 3. Heat flows from a hotter body to a colder body in contact with it.

Concept 3-a (p. 55): Heat will flow from one substance to another in contact with it until the two are equally hot.

1. Take two beakers containing water. Warm one over a spirit lamp and note the temperature of the water. Note the temperature of cold water in the other beaker. Pour the hot water into the

beaker of cold water, stir it and note the temperature. Which water is gaining temperature, or in other words, which water is absorbing heat? Which water is losing temperature and therefore giving out heat?

Repeat the experiment but reverse the order, i.e., pour cold water into the hot water. Which water is gaining heat and which is losing heat?

At what point will neither gain nor lose heat?

Fig. VI. 14 shows how this transfer of heat energy takes place. The molecules of A, represented by shivering figures, have little heat energy. Therefore block A has a low temperature —it is cold. The molecules of block B, shown as jumping figures, have a great amount of heat energy. Therefore block B has a high temperature—it is hot. Blocks A' and B' represent the situation when some of the heat energy of B has been transferred to A in the form of heat. Now both blocks have equal amounts of heat energy; their temperatures are the same.

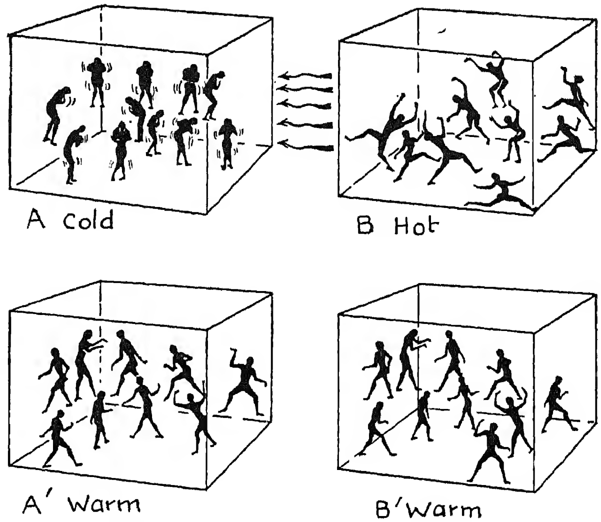


Fig. VI.14. Transfer of heat energy.

Concept 3-b, c (p. 55): (b) Heating a solid makes the particles (molecules) of the substance vibrate faster.
(c) The vibrating particles take up more room and the substance expands as it is heated.

1. To show how when a substance is heated that the molecules of the substance vibrate faster and so push each other further apart thus taking up more room: simulate this by placing several marbles in a shallow pan with straight sides and shaking the pan first gently and then more and more vigorously. As the pan is shaken, the marbles spread out over a larger portion of the pan than before. (Slightly tilt the pan so that when the marbles are not being shaken, they roll to one side of the pan.)

2. Partly fill a small jar with rice grains and seal the jar. Then shake the jar gently at first and then more vigorously. Note that as above, the rice grains spread out within the jar as they are shaken.

Major Concept 4. Temperature is the degree of hotness of a body. The expansion of a substance enables us to measure temperature. For example, the hotter the material in a thermometer, the more it expands.

Concept 4-a (p. 55): Common thermometers are filled with mercury, or with coloured alcohol. Both these substances remain liquid through a wide range of moderate temperatures, and so are appropriate for domestic purposes.

To explain the use of mercury or alcohol do the following;

1. Through a few narrow glass tubes suck some clean water, coloured water, coloured alcohol and

mercury and see which is seen more distinctly. Now allow the liquid in the tubes to fall. Observe in which tube the liquid sticks the least.

2. Take about 1 ml of each liquid in narrow test-tubes separately and warm each for 5 seconds. Find by touching which is warmed most quickly.

3. Keep the above test-tubes in a freezing mixture (crushed ice and common salt) for 25 minutes and find out which one gets frozen. Then warm the tubes over spirit lamps until the liquids begin to boil. (*Caution*: Mercury vapour is poisonous.)

Correlate the results with the use of mercury and alcohol in most thermometers, (i.e., where very high temperatures are not required to be measured).

Concept 4-b (p. 55): The first thermometers used air as the expanding substance.

To make an air thermometer, fit a flask made from a used electric bulb with a one-holed stopper and with a 60 cm. glass tubing in it. The stopper must be sealed air-tight by dropping molten wax from a candle. Support the bulb on a wooden stand as shown in the figure. Paste a strip of paper for a scale behind the tube. Place the lower end of the tube in a bottle of cold coloured water. Warm the bulb gently to drive out some air so that when the bulb cools to room temperature the coloured water may rise to about half way in the tube.

Calibrate the water level of this thermometer with a standard mercury or alcohol thermometer at two different temperatures and mark the spaces accordingly.

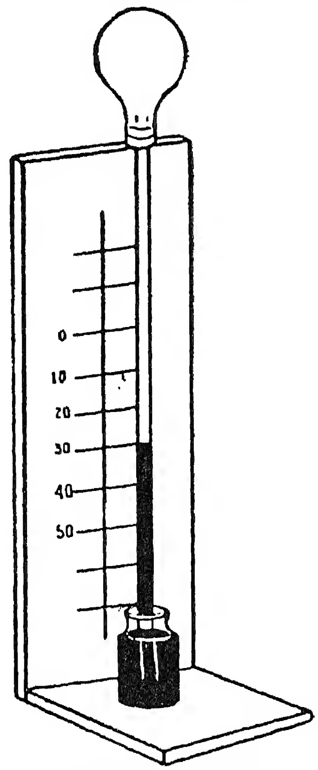


Fig. VI.15. An air thermometer.

Concept 4-c (p. 55): Compound bars of two metals which expand at different rates are used in measuring temperature.

To explain the use of bimetallic strips for measuring temperature, rivet two equal strips of iron and brass together by making holes with a nail and using small tacks as rivets. Place rivets about 5 cm apart.

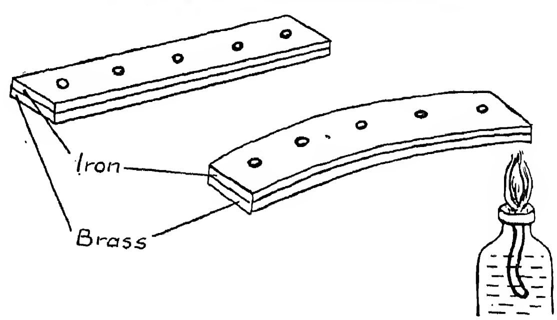


Fig. VI.16. Effect of heat on bimetallic strip.

Warm the strip over a flame to see how it bends. Explain how this bending may be used to move a lever or a needle to indicate difference of temperature.

The end of a bimetal strip moves through a curved path much more than the actual increase in length in each of the metal strips individually. This magnifying effect is used in a thermostat, a mechanical device for maintaining temperature. Thermostats are used wherever temperature has to be controlled. Figure VI.17 shows one type of thermostat. When the temperature drops, the coiled bimetal strip unwinds causing the movable arm to move counter clockwise. This closes a switch and completes an electric circuit. This starts the motor of the oil burner. As the temperature rises above the point at which the thermostat is set, the bimetal strip winds, breaks the contact and stops the motor.

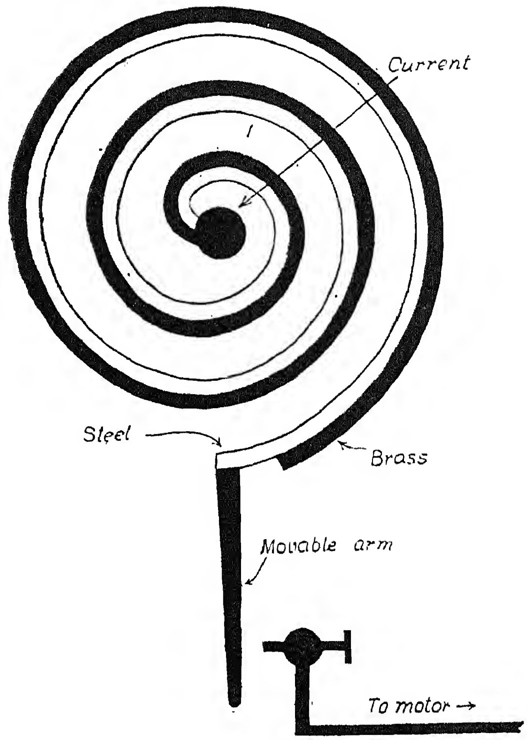


Fig. VI.17. A (bi-) two metal thermostat.

Concept 4-d (p. 55): Clinical thermometers have a constriction which keeps the mercury up in the tube of the thermometer.

To explain the importance of the constriction in a clinical thermometer show the following:

1. On a cool day put the bulb of an ordinary thermometer in the mouth of a pupil for 1-2 minutes and while it is still there note the temperature. Then take it out and keep it in air for a while and note the temperature. Are both readings the same?

2. Shake the mercury of a clinical thermometer down and keep the bulb in the mouth of a pupil for 1-2 minutes and take the reading while the bulb is inside the mouth and again after taking it out. Are both the readings the same?

3. Put the bulb of a clinical thermometer in lukewarm water (not exceeding 100°F) for 1 minute. Take it out, note the temperature and place it again in cold water for 1 minute and note the temperature as shown on it. Are both readings the same?

4. Repeat the above experiment but shake the thermometer both before and after placing the bulb in cold water. Are both readings the same?

Concept 4-e (p. 55): All liquid thermometers have a sizeable bulb which opens into a uniform bore capillary tube. A little expansion of the liquid in the bulb forces the liquid a considerable distance in the capillary tube.

Collect as many kinds of liquid thermometers as you can—Centigrade, Fahrenheit, clinical, alcohol, a maximum-minimum thermometer, etc. Examine them and draw sketches to show that all have a bulb containing some liquid, a stem with a narrow bore in which the liquid expands or contracts and the end of which is sealed, and a scale.

Major Concept 5. The quantity of heat is measured in calories.

Concept 5-a (p. 55): A match flame has less heat than a vessel containing water, yet the match flame is hotter than the vessel of boiling water.

To show that a match flame is hotter than a beaker full of hot water, note that the tip of a needle held in a match flame becomes red hot, but it does not become red in boiling water.

Concept 5-b (p. 55): A white hot pin contains less heat than a red hot nail, yet the pin is hotter than the nail.

To show the different amounts of heat in a white hot pin and red hot nail, first take two equal-sized beakers and take equal amounts of tap water in each (say 50 gm.). Record the temperature of water in both.

Heat the pin over a spirit lamp with a pair of tongs till it is white and plunge it into one beaker. Stir carefully with the thermometer and note the rise of temperature.

Similarly heat the nail red hot on a flame, repeat as in the previous case, and note the rise in temperature.

Which beaker has shown a greater rise of temperature? How can this be accounted for? (See concept 5-b.)

Concept 5-c (p. 56): The unit of heat is the calorie, i.e., the amount of heat required to raise the temperature of one gramme of water through one degree centigrade.

To understand the idea of a unit of heat, suspend a tin containing say, 100 grammes of water. Insert a thermometer into the water and note the temperature. Now heat the water over a spirit lamp. Record the time taken to raise the temperature of water by 10°C. The number of calories of heat absorbed is mass in grammes (100 gm.) multiplied by the number of degrees centigrade of change in temperature (10°C).

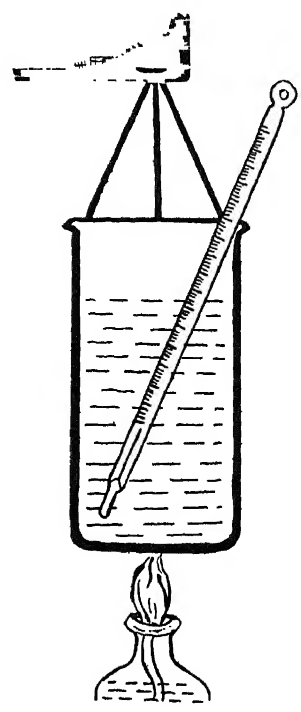


Fig. VI.18. The idea of a calorie as the unit of heat.

Major Concept 6. One of the ways in which heat is transmitted is by conduction.

Concept 6-a (p. 56) : In conduction the heat is transmitted from particle to particle without the particles moving from their places.

Fix a number of small tacks (pins) by melted candle wax at intervals of 3 cm. each on a long brass or copper rod of about 30 cm. in length. Fix the bar to a clamp stand or fix a handle so that it can be held and heat one end of it by a spirit lamp. Observe and deduce that heat moves from the heated end of the bar by *conduction* until the entire bar is heated.

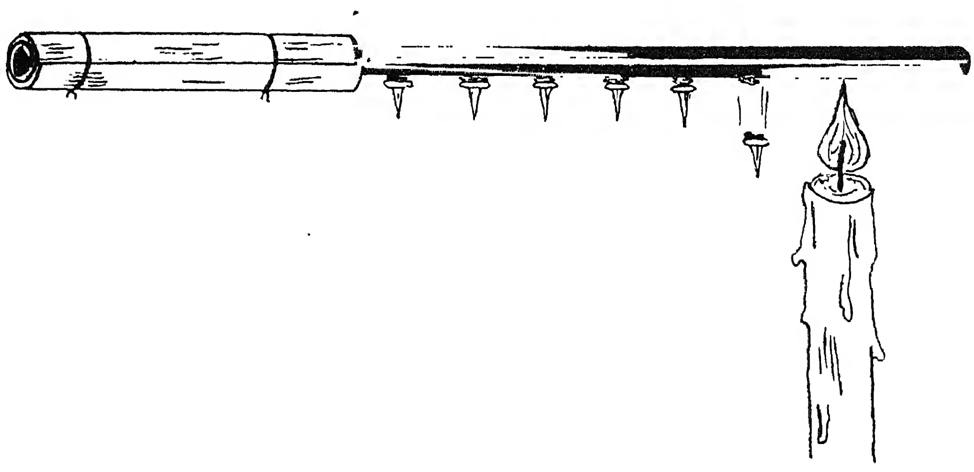


Fig. VI.19a. Heat travels through bar by conduction.

Concept 6-b (p. 56) : In conduction the rapidly moving molecules hit against their neighbours, thus speeding the latters' movement. In this way, heat is transferred by the passage of energy from one molecule to another.

Suspend a number of ping-pong balls or rubber balls by means of hooks on a plank kept horizontally so that all the balls become still.

Now push the ball on one extreme end so that it strikes the next one. See how this movement is carried to the other end through all the balls.

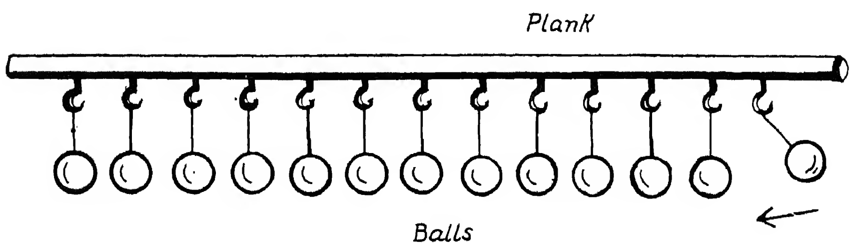


Fig. VI. 19b. Transmission of heat from particle to particle.

Major Concept 7. Most metals are good conductors. Most non-metals, liquids and gases are poor conductors.

Concept 7-a, b (p.56): (a) Most cooking utensils are made of metals which are good conductors.

(b) Poor conductors of heat (insulators) are useful in handling hot things and in keeping warm or cool:

(*i*) Asbestos is one of the best solid insulating materials.

(*ii*) Trapped still air is one of the best insulating materials.

Ask pupils to list

1. the common utensils they see used at home and to state whether or not they are good conductors.
2. materials that are used for handling hot objects.
3. fabrics which are used to keep the body warm in winter and the special feature which enables them to do so (wool, silk, fur, feather, leather, etc.).

Major Concept 8. Heat moves in liquids and gases chiefly by convection.

Concept 8-a,b,c (p. 56): (a) In convection the heated particles move from the place where they are heated to the cooler portions of the liquid or gas.

(b) Convection currents carry heat up but not down. For example, when heating a kettle of water,

(*i*) the kettle is heated at the bottom.

(*ii*) The molecules of water at the bottom first receive the heat. As they are heated, they move faster and hence the water at the bottom expands. The heated portion of the water then becomes lighter in weight than the cooler portions.

(*iii*) The heavier cool water settles to the bottom, lifting the lighter heated water. In this way a convection current carries the heat from the bottom of the kettle throughout the entire vessel.

(*iv*) In this way each molecule of water derives heat directly from the source.

(c) Winds are convection currents in the atmosphere.

1. To show that in *convection* heated particles move from the place of heating to cooler portions, fill a jar or flask with water. Drop some fine grated blotting paper particles and allow them to settle to the bottom. Now carefully place the jar over a spirit lamp and warm it. Observe the path taken by the particles of paper. They follow the convection current set up by water molecules.

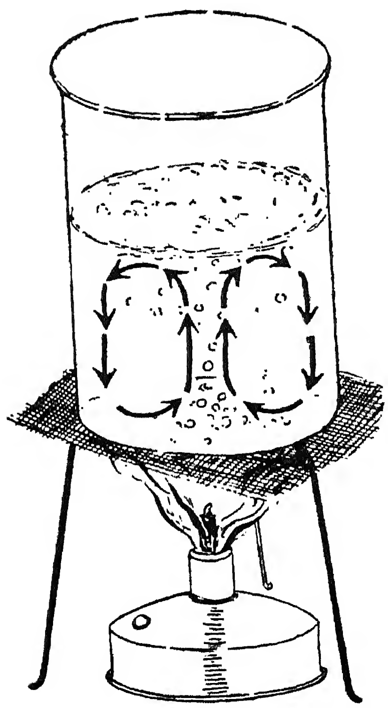


Fig. VI.20. Heat through convection.

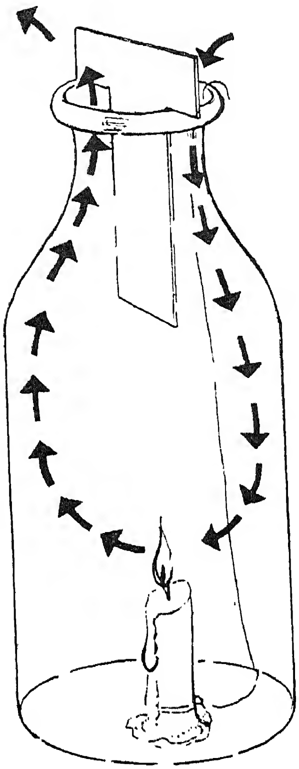


Fig. VI.21. Convection currents in air.

In the place of grated blotting paper, a crystal of potassium permanganate will also make visible the movement of water currents set up by convection.

2. To see convection currents in gases, set up a cardboard box with a glass front and two openings on the top at some distance from each other. Fit a lamp chimney or paper rolled like a hollow cylinder in each in these holes. Light a candle and fix it below one of the chimneys and immediately close the glass door. Then bring a smouldering paper near the opening of the two chimneys by turn. What does the up and down movement of smoke in the two chimneys indicate regarding the movement of air particles in the box? This can be done in a bottle also, as in Fig. VI. 21.

3. To show that warm air is lighter than cold air, balance two bottles or two flasks of about a litre capacity at the ends of the two arms of a balance with loops of string as shown in the figure. Warm one of the bottles gently by means of a spirit lamp or candle. Observe the effect. Allow the bottle to cool to room temperature and observe again. Repeat this with the other bottle.

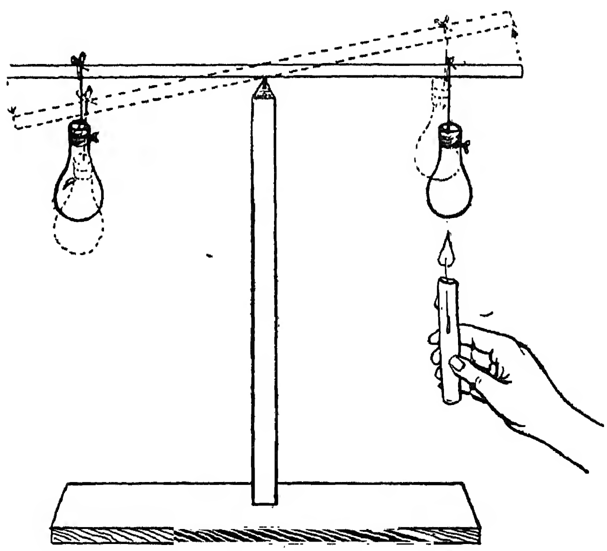


Fig. VI.22. Warm air is lighter than cold air.

4. Fill a jar or flask with cold water up to a certain mark and weigh it. Then fill the same

jar up to the same mark with hot water and reweigh it. What is the difference in the two cases? For the same volume of water which one is heavier?

5. Fix an ink bottle with a two-holed cork. Through one hole pass a tight fitting glass jet and through the other hole pass a glass tubing about 5 cm long as shown in the figure. Fill the ink bottle with warm coloured water and close it with the cork and quickly place it on the bottom of a larger jar filled with very cold water. Observe the hot coloured water moving up to the top of the vessel as the cool clear water moves down to the bottom of the ink bottle.

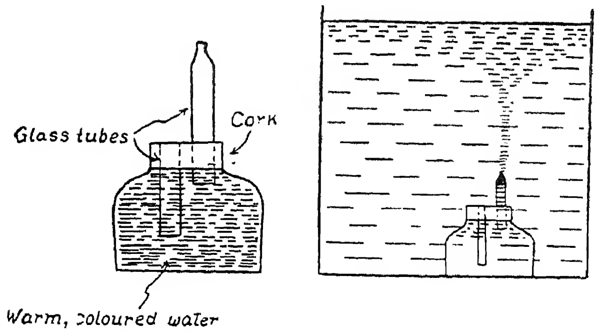


Fig. VI.23. Heat transfer by convection.

Major Concept 9. Heat can pass through a space without a medium by the process of radiation. Such heat is called radiant heat.

Concept 9-a (p. 57): We receive radiant heat energy from the sun through space. When we sit by the side of a fire, radiant heat reaches us without heating appreciably the air between us and the fire.

1. To show that heat can be received by radiation, hold your palm upward under an unlighted electric bulb. Switch on the bulb and observe that you feel the heat instantly. This heat could not have reached your hand by conduction as air is a poor conductor.

Could this heat have reached by convection downwards? It could not, for convection currents carry heat up, not down.

In this case, heat has reached from its source downwards to a body by a wave motion in the same way that the sun's energy reaches the earth. This mode of transmission is called *radiation.*

2. To show that radiant heat does not warm the medium through which it travels, hold a reading glass in the sun and focus the rays on a wad of thin paper or cotton wool. Observe that after a short time the paper or cotton becomes hot enough to catch fire. Is the lens also equally hot ?

Concept 9-b (p. 57): Radiant heat flows in straight lines.

Stand near a stove or fire, and you will feel the warmth coming from it on your face. Now place a shield of cardboard or a notebook between your face and the fire and observe the difference. Could this have happened if heat travelled around the cardboard in curved lines?

Concept 9-c (p. 57): When radiant heat is absorbed by a body, the body gets hotter; the molecules in the body move faster.

Take a beaker half full of water and note its temperature. Place it in the sun and note down the temperature again after 15 minutes. Is there any rise in the temperature?

Repeat the experiment with another beaker containing water, but kept in the shade where no direct sunlight reaches it. What is the difference in this case?

Concept 9-d (p. 57): A black and rough surface absorbs radiant energy better and reflects it less than a bright smooth surface.

To show the difference in absorption of bright and black surfaces, cut the top and base of a half kilo 'Dalda' tin to make it into a hollow cylinder. Cut two vertical slits on opposite sides of the cylinder so that the surface is divided into two equal parts. Blacken the inside of one half, leaving the other half shiny. Fasten two match-sticks to the centre of the two surfaces with a drop of molten wax.

Place a lighted candle in the centre of the cylinder and observe which matchstick falls first.

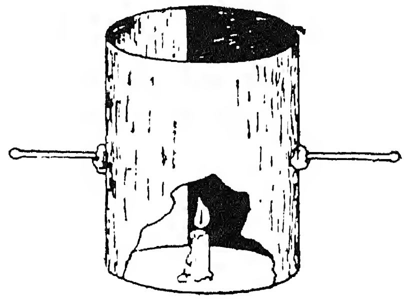


Fig. VI.24. Black and bright surfaces affect radiation differently.

Concept 9-e (p. 57): A black rough surface radiates more heat energy than a bright smooth surface.

Place two tin cans on an insulating surface such as a folded newspaper or a small wooden board. Fill both tins with hot water from the same vessel so that the temperatures will be the same to begin with. Then, by holding a thermometer with the bulb of the thermometer in the centre of each can of water, take the temperature of each at five minute intervals. Record the data obtained in a table, and then later construct a line graph to compare the rate of cooling of the hot water in the shiny tin can and in the black sooty can.

Major Concept 10. A thermos flask is a vessel designed to limit the flow of heat energy through its walls by any of the modes of transmission.

Concept 10-a,b,c,d (p. 57):

(a) The thermos flask is a double-walled glass vessel with a vacuum between the walls. The inner walls are silvered.

(b) The passage of heat by conduction and by convection are almost stopped by the vacuum between the walls.

(c) The passage of heat by radiation is almost stopped by the mirrored surface.

(d) The cork also limits the transmission of heat by each of these methods.

To see the working of the thermos flask, get one in working order and a bottle which holds the same quantity of water.

Keep some ice or hot water by turn in the flask and in the bottle. With the help of a thermometer, observe that there is no appreciable

change in temperature in the thermos flask. Deduce that *both* loss and gain of heat are lessened.

Then take the thermos flask and let the pupils observe

(1) the double-walled construction
(2) the two silvered surfaces
(3) the place of sealing after air has been removed from the space between the double walls.
(4) the way the bottle rests on cork or felt pads and
(5) the lid of cork.

Discuss the various ways of transmission of heat and how transmission is stopped or minimised.

It should be clarified that the transmission cannot be stopped but it can retarded.

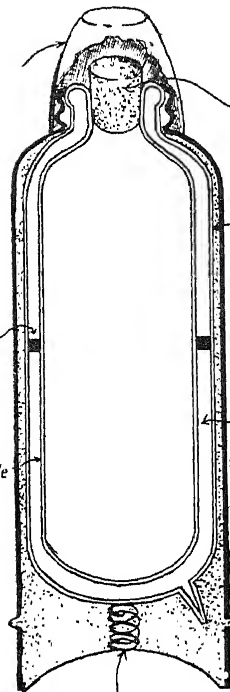


Fig. VI.25. Thermos flask.

Sound—How Produced and Propagated

Major Concept 1. A body in a state of vibration produces sound.

Concept 1-a, b (p. 57): (a) Sounds are produced when something vibrates.
(b) Vibrations can often be felt or seen.

1. Take a ruler with a hole at one end. Tie one end of a stout thread (about one metre long) at the hole. Make a loop at the other end. Pass one finger through the loop and swing the ruler in circles, faster and faster. Repeat the experiment using different lengths of thread and observe the difference in sound produced.

2. Stretch a twine tightly between two nails fixed at a distance of about 40 cm apart on a plank. Pluck the string and note the vibration of the twine and the sound produced. Repeat the experiment by altering the distance between the nails and using varying thicknesses of string.

3. Pour a little water in a shallow circular tray. Tap the edge of the tray gently with a pencil. Note the sound produced and the ripples made on the surface of the water.

4. Say, 'ah......' and prolong it and feel your wind pipe with your fingers. What causes the vibrations? Feel your voice-box while speaking, singing and whistling.

Concept 1-c, d (p. 58): (c) The number of times a body vibrates per second is known as the frequency.
(d) The human ear can hear sounds of frequencies from 20 to 20,000 per second.

1. Suspend a piece of lead or a small ink bottle filled with sand by a strong thread from the top of a door frame. Let the object swing freely as a pendulum does. How many swings does it make

in a minute? Lengthen and shorten the thread and similarly count the number of swings or vibrations. Observe how the shorter the length of the string, the faster are the vibrations. You may also observe the vibrations made by the children's swing in your school.

2. Take a couple of tuning forks with different frequencies. Tap and let the forks vibrate by turns. Note the difference in the sound produced.

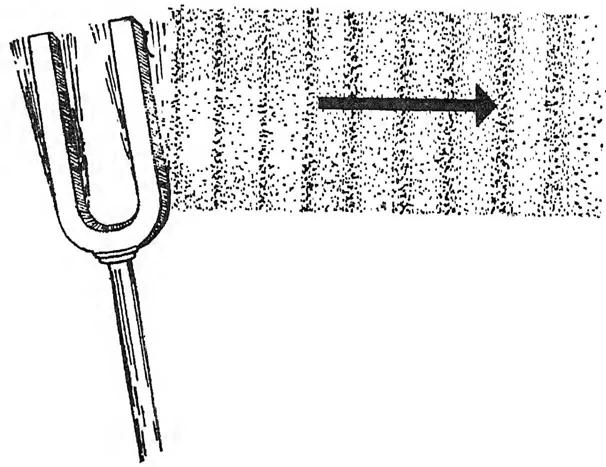


Fig. VI. 26. Sound waves of a tuning fork.

Compare the vibrations of the tuning fork with the pendulum swing. The number of vibrations made in one second is called 'frequency.'

Major Concept 2. Sound waves travel outwards from the source in all directions.

Concept 2-a, b (p. 58): (a) Vibrating objects push the air molecules around them. These molecules in turn push other molecules which surround them.
(b) In this way a sound wave moves out from vibrating objects.

1. Build a simple rack that will hold about 50 marbles of the same size and some space at each end. Nail a narrow strip near the edge to form a groove. Nail two small pieces of wood to the back to hold the rack in an inclined position. Keep the rack on a table and place marbles in the groove. Keep a small bowl at the end of the rack to receive the falling marbles.

Now roll the first marble at end A forcefully against the next one. What happens to the marble at end B? Does the motion pass successively from marble to marble?

Similarly, air molecules pass motion from one molecule to another molecule. However air molecules bump each other elastically rather than as hard marbles.

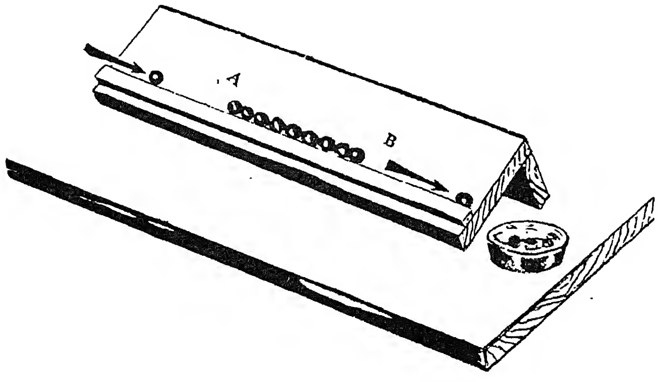


Fig. VI. 27a. Vibrating objects push air molecules.

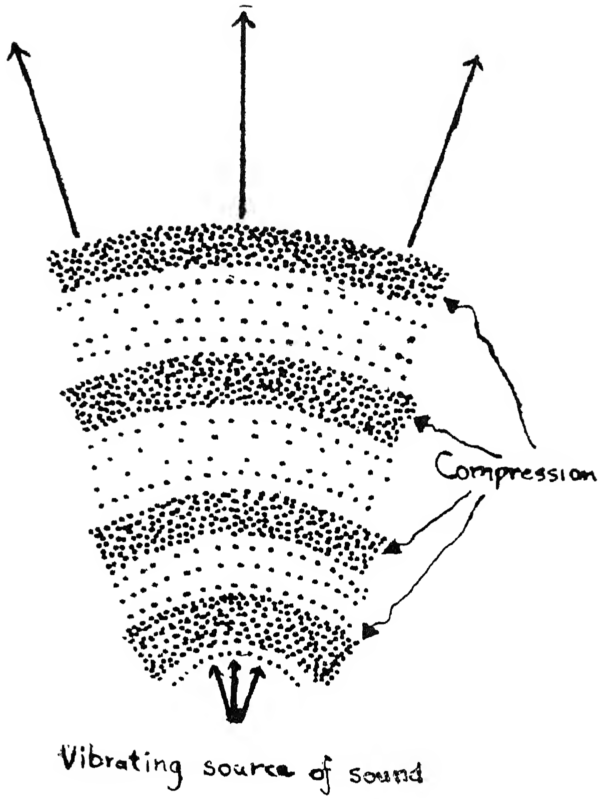


Fig. VI. 27 b. Diagram of the movement of a sound wave.

2. The transmission of sound from molecule to molecule may be simulated by the following class experiment. A group of ten or more students should stand in line, one behind the other, each placing his hands on the shoulders of the student in front of him. Each student represents a molecule. The student (molecule) at the rear now pushes the shoulders of the student (molecule) in front of him who then in turn pushes the student in front of him and so on, up the line. It will be noticed that a single push, or compression, passes along the line. Now repeat the experiment except that the person at the rear should push and then pull at a regular rate; each person up the line passing on the pushes and the pulls. Evenly spaced waves will be seen following one another along the line. You will notice that in this model of sound waves, the 'molecules' move back and forth along the line of movement of the waves.

3. To illustrate how sound energy travels through an object from particle to particle in all directions, set a few empty match boxes about an inch apart in two rows crossing at right angles to each other as illustrated. Drop a small ball directly at the intersection. The behaviour of the boxes will help to show what happens in air or any medium when an object vibrates to cause sound. The energy is transmitted from particle to particle of the air in all directions until it reaches the ear-drum and strikes against it.

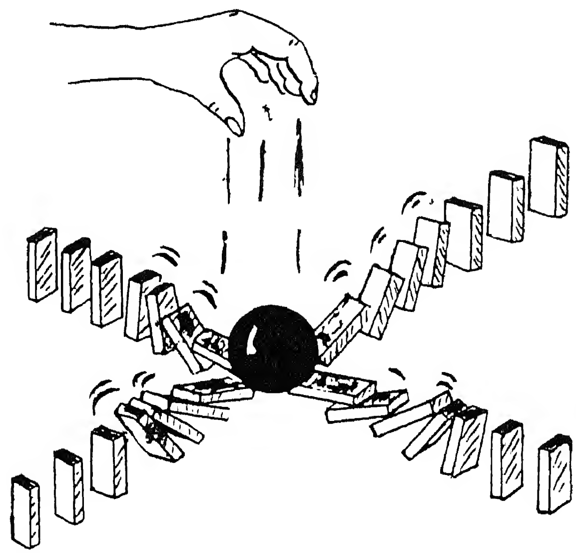


Fig. VI. 28. How sound waves are propagated.

4. To visualise how air would appear if the sound waves could be seen as they ripple through it, draw Fig. VI.29a on a sheet of paper and

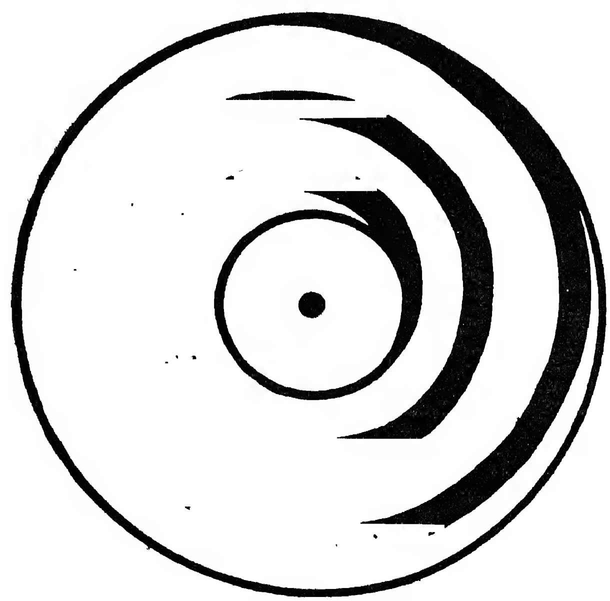


Fig. VI.29.a Sound waves move out in all directions.

fix it on a cardboard disc. Make your pivot by fixing a pin to the rubber-tip of a pencil. Pass the pin through the disc before fixing it in the rubber. Now rotate it clockwise. See the effect produced in all directions from the vibrating object. The effect should be a beautiful smooth movement like waves travelling from the centre outwards.

Major Concept 3. A medium is necessary for sound waves to travel.

Concept 3-a **(p. 58)****:** Sound waves travel through the air and reach the ear.

1. Close the room tightly and plug the ears of a pupil with cotton wool. Ask another child to whisper or whistle from outside the room. Can his voice be heard by the child with plugged ears? Remove the plugs of cotton wool and find if he can now hear the sounds. Finally open one door or a window and find out how much better he can hear now. Why?

2. Sound waves need a medium like air through which to travel. Make a vacuum pump and a vacuum receiver in the following way:

Vacuum pump: Open a bicycle pump and remove the piston. Unscrew the bolt that holds the leather washers. Reverse the washers by turning them over. Replace washers on the piston and insert into the pump cylinder.

Reverse the valve at the base of the pump by unscrewing the hose connection and improvising a way to connect it so that it keeps air from coming out of the pump.

Vacuum receiver: Take a large fruit jar with an air-tight screw cap. Drill a hole through the top. Have a short metal tube soldered in the hole so that it is air-tight. Finally solder a tyre valve upside down at the lower end of the tube. Now you have a vacuum receiver.

Tie two small bells inside the vacuum receiver. First shake the receiver with air inside. Can you hear the bells ringing? Now screw in the cap tightly. Remove the air from the receiver with the pump. Shake the receiver again. Can you now hear the bells ringing as clearly as before? What has brought about this change? Sound is transmitted by the movement of the air molecules from the bells to the ear. Without air to transmit the vibrations, no sound can leave the jar.

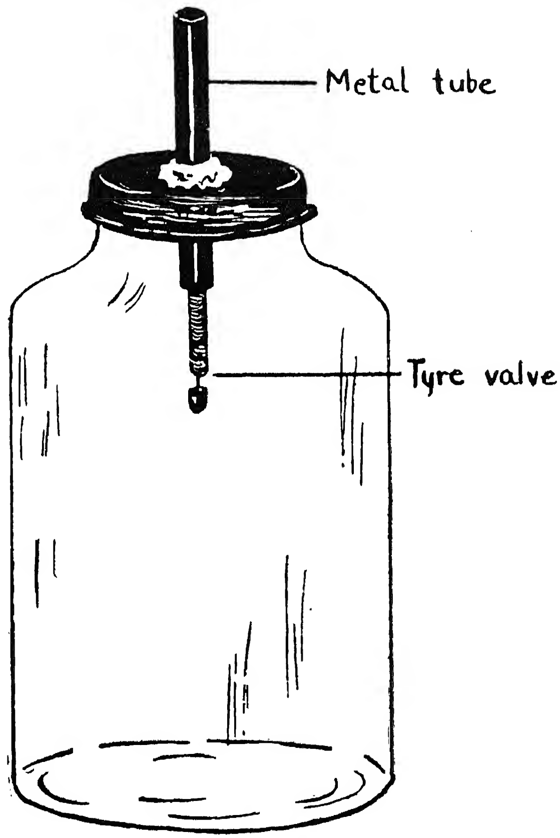


Fig. VI.29b. An improvised vacuum receiver.

Another way to produce a vacuum in a jar is to put a little water in the bottom of the jar and then to boil the water vigorously to make the water vapour or steam drive the air out of the jar. Then while the water is boiling vigorously, seal the top with a stopper or a cover. (The two small bells can be attached to the inside of the cover or stopper.) As the jar cools, the water vapour inside the jar will condense making a good vacuum.

Then the jar may be shaken as above to try to make the bells ring. Can you hear them ring.

3. Take a long garden hose open at both ends. Use it as a telephone line for talking and listening to another person at the other end. What is carrying the sound?

Concept 3-b (p. 58): Sound waves also travel through liquids and solids.

1. Keep one ear in contact with one end of a long iron pipe and ask someone to tap the pipe at the other end. Can you hear the tap distinctly? Now move your ear away from the pipe but still close to it. Can you hear the tap now?

2. The same effect may be felt if the ears are kept close to the iron rails when a train is coming from a distance. (This should, however, be done very cautiously).

3. Close your left ear with the palm of your left hand. With your right hand strike the back of your left hand. Can you hear the sound? Now take your hand a small distance away from the ear, but continue to strike, can you hear now?

4. Construct a string telephone. Secure two used tin cans without lids. Punch a fine hole in the centre of each can. Thread several metres of thin cotton string through the holes. Attach a match stick at each end of the string so that the string does not slip out of the holes.

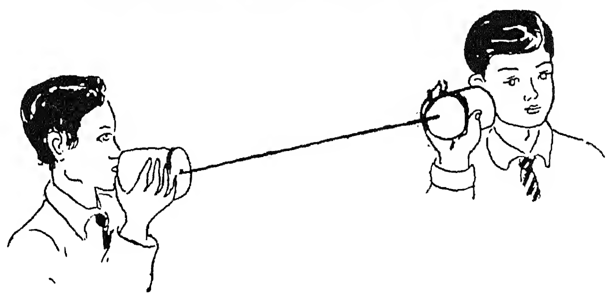


Fig. VI.30. Solids carry sounds.

You hold one end and let your friend hold the other. Stand apart at sufficient distance to hold the string taut. Using one can as speaker and the other as a receiver. You can carry on a 'telephone' conversation.

5. To show that liquids also carry sound, place your head under a pool of water so that your ears are immersed. Let someone strike a gong or bell under water. Can you hear the sound coming through the water ?

Musical Instruments

Major Concept 4. There are many ways to set an object vibrating.

Concept 4-a, b (p. 58): (a) Sounds of certain musical instruments are produced by striking or blowing.
(b) Plucking also causes objects to vibrate.

There are many ways of producing sound vibrations. Do the following:

1. Arrange four or five cups with varying amounts of water. Tap the edge of each sharply with a pencil.

2. Stretch a few pieces of rubber threads or elastic bands of different lengths tightly on a wooden board on which nails have been fixed at different distances. Pluck each separately to see what kind of sound is produced.

3. Take a few small glass vials or bottles of the same diameter but of different lengths. Blow across the open end of each bottle. A sound of a definite pitch should be produced. Is the pitch the same for the different vials or different? Is the pitch of the sound related to the length of the vial? Account for any differences you observe.

4. Make a bow with a strip of bamboo and horse hairs or an elastic stretched string. Pluck the string of the bow. See if sound is produced.

Thus objects may be made to vibrate by striking, plucking or blowing.

Major Concept 5. There are many kinds of musical instruments depending upon the nature of the vibrating body.

Concept 5-a,b,c (p. 58):	Musical instruments may be (a) stringed, (b) wind or (c) percussion.

1. To show the functioning of stringed musical instruments make a cigar box violin.

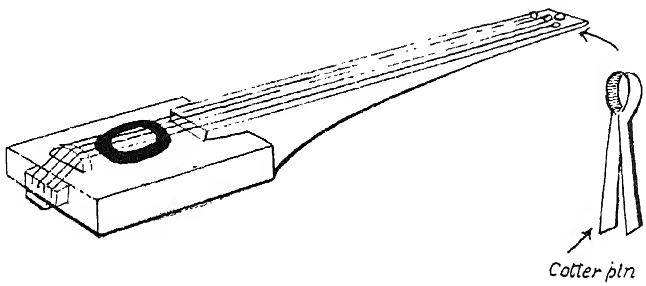


Fig. VI.31. Cigar box violin.

Take a cigar box or a similar wooden box and regular strings as used in a sitar or violin, a piece of rosin, some scraps of wood and some cotter pins. Cut a round hole in the top of the box. With the help of glue or suitable wood-adhesive, assemble the violin as shown in the figure.

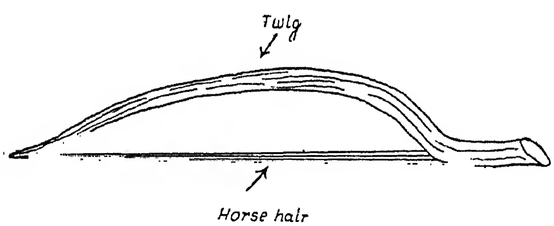


Fig. VI.32-a. A horse hair bow for a violin.

A bow may be made from horse hair and a twig about 70 cm. long as shown in the figure above. The pitch of the sound produced by the violin may be changed as follows:

1. Alter the tension by turning the cotter pins, thus tightening the strings.

2. Alter the length of string by pressing the wire at different distances.

3. Use the same lengths of different wires with different diameters.

2. Observe how musicians who play on stringed instruments produce different notes by the movement of fingers. Also observe how they tighten and loosen the strings while tuning.

3. To show the functioning of wind instruments, make a bottle and tube trombone. Take a glass tube about 20 cm. long and about 1 cm. in diameter. Take a 2 litre bottle nearly full of water. Hold the bottle in one hand and the tube in the other. With one end of the tube dipping in water, blow into the tube moving the bottle up and down taking care to keep the other end

Fig. VI.32 b. Bottle glass trombone.

immersed in water. Observe how the pitch is altered as the length of the air column is increased or decreased. Also observe how the pitch is altered by the method of blowing.

Fig. VI.32. c. A home made flute.

4. Call attention to the position of the different holes in a flute and how different notes are produced by varying the length of air columns.

You can make your own flute. Secure a piece of straight bamboo about 1.5 cm. in diameter and 30 cm. long, open at both ends. Dry it by holding it over a small fire until it turns yellowish brown. When it cools make the mouthpiece and a row of holes as shown in the figure. The holes provide a way by which the length of the air column can be changed. Close the holes alternately with your finger and blow and notice the different notes produced.

Observe how the tabla player tunes his 'tabla' by tightening or loosening the ropes tied to the leather surface. (He moves the iron rings attached to the ropes to do this.)

Major Concept 6. The pitch of a stringed instrument may be altered by changing—

Concept 6-a,b,c (p. 58): (a) The tension of the string
(b) The length of the string
(c) The thickness of the string

See Concept 5 (a) above.

Major Concept 7. The pitch of a wind instrument may be altered by changing—

Concept 7-a,b (p. 58): (a) The length of the air column
(b) The method of blowing

See Concept 5 above.

Major Concept 8. The pitch of percussion instruments may be altered to a limited extent by—

Concept 8-a,b (p. 58): (a) Changing the tension of the vibrating surface;
(b) Having different-sized instruments.

See Concept 5 above.

MAGNETISM

Major Concept 1. A magnet attracts some things and not others.

Concept 1-a, b (p. 59): (a) A magnet attracts iron, steel, nickel and cobalt.
(b) A magnet does not attract other metals, glass, wood or other substances.

To see what materials a magnet attracts, try picking up things made of iron, steel copper, nickel, aluminium, glass, paper, rubber, wood, etc.

Major Concept 2. A magnet has two poles: a north pole and a south pole.

Concept 2-a (p. 59): The ends of a magnet attract more than any other part. Those ends are called the poles.

To see what part of a magnet attracts most, dip a magnet in a tray of iron filings and note where the iron filings cling most. The points where the iron filings are attracted most are called poles. (Iron filings may be procured as waste materials from a machine shop.)

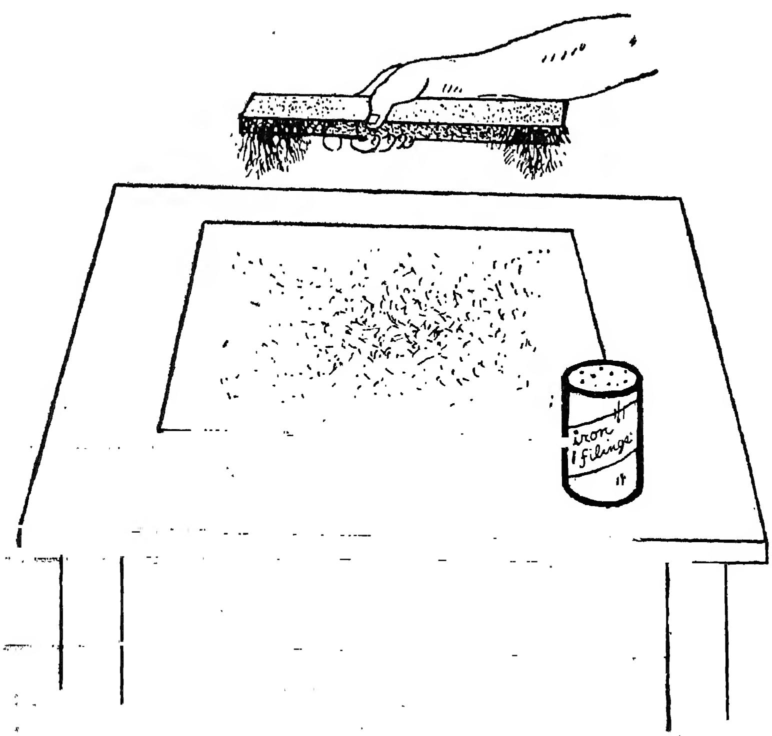


Fig. VI.33 a. To see what part of a magnet attracts most.

Concept 2-b (p. 59): A suspended or pivoted magnet points north and south.

To name the poles, suspend a magnet in a stirrup by a string so that it is free to turn. When it comes to a standstill, note that one end points north and the other south. The end which points north is called the *north pole* and the end which points south is called the *south pole*.

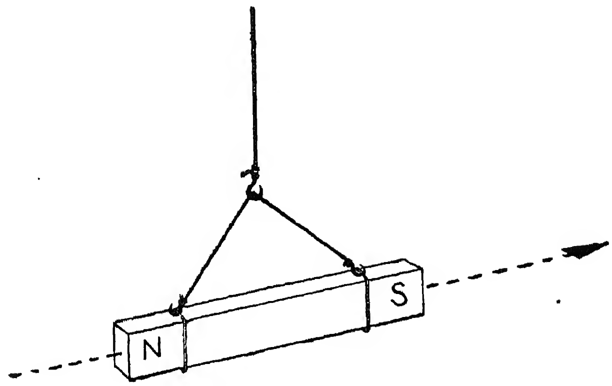


Fig. VI.33 b. How to find the poles of a magnet.

Concept 2-c (p. 59): Like poles repel, unlike poles attract.

To see how north and south poles affect each other suspend one magnet and wait till it stops moving. Now bring the north pole of another magnet, near the north pole of the suspended magnet. What happens? Then bring the north end of the magnet near the south end of the suspended magnet. Do the poles now attract or repel? How do like poles affect each other and how do unlike poles affect each other?

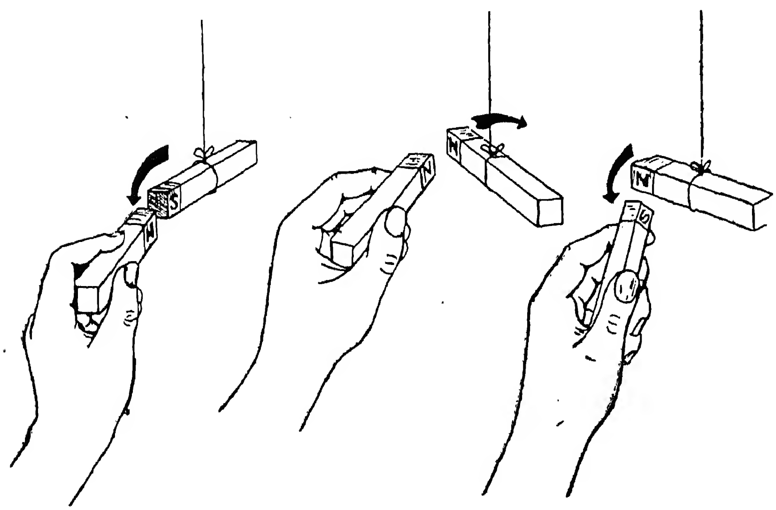


Fig. VI.34. To show how north and south poles affect each other.

Concept 2-d (p. 59): Every magnet has a magnetic field around it.

To show the lines of force about a magnet, place a pane of glass or an aluminium plate above a bar magnet and sprinkle iron filings on the glass or tray from a height of about two feet. Tap the

glass or plate lightly with a pencil, and observe how the iron filings arrange themselves. Note the lines of force about the bar magnet.

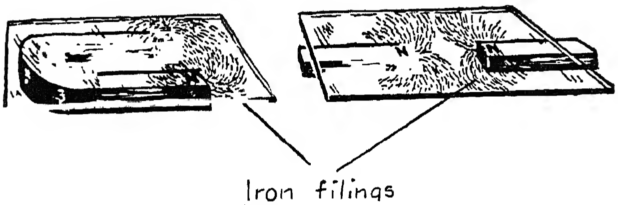


Fig. VI.35. To show lines of force about a magnet.

Similarly show the lines of force around a horse-shoe magnet, a U-shaped magnet, around two north poles of two bar magnets placed close together, around two bar magnets so placed that the north pole of one and the south pole of the other are placed close together.

Hold one end of a nail in iron filings. (See Fig. VI.36.) Bring the pole of a well-magnetized magnet near, but not touching the nail. Lift the nail and magnet as a unit. What happens? Change the distances between the nail and the magnet and observe what happens.

You will notice that the iron filings line up in an orderly manner between the north and the south poles. These long covered lines are called the magnetic *lines of force.* The space around the magnet in which it attracts magnetic materials is called the *magnetic field.* The magnetic field includes all the magnetic lines of force. Lines of force are said to go from the north pole to the south pole in the space around the magnet, and from the south pole to the north pole within the magnet.

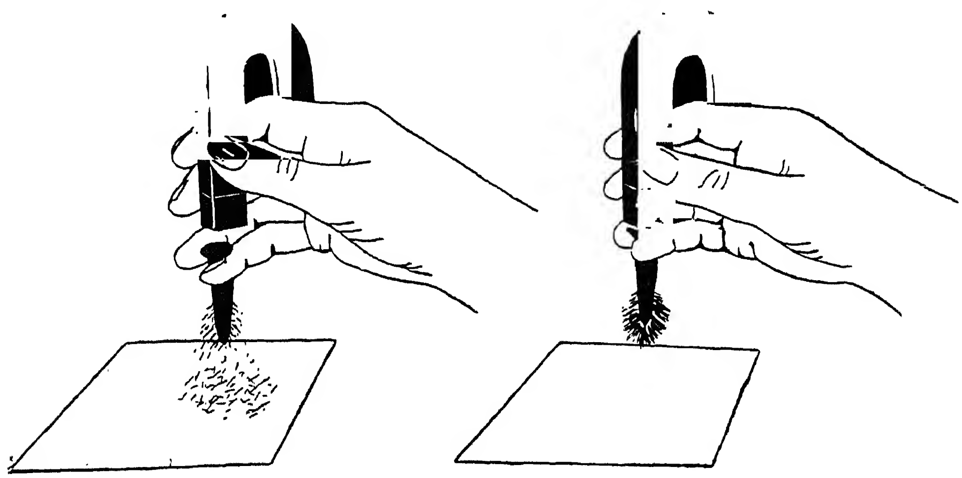


Fig. VI.36. To show the field of force about the pole of a magnet.

Major Concept 3. Magnetism will pass through any substance except those which it attracts.

Concept 3-a, b (p. 59): (a) Magnetism will pass through glass, paper, wood, aluminium.
(b) Magnetic field is affected by iron, steel, nickel and cobalt.

Get thin sheets of as many different kinds of materials as you can such as cardboard, glass, iron, aluminium, paper, rubber and wood. Drop some iron filings on each one. Move a magnet around under the first one and then another and see if the magnet attracts iron filings through these materials. In the case of the sheet of iron, compare the attraction of the magnet through it at the centre with the attraction at the edges of the sheet. Account for what you observe. Which material is the most effective shield against magnetism?

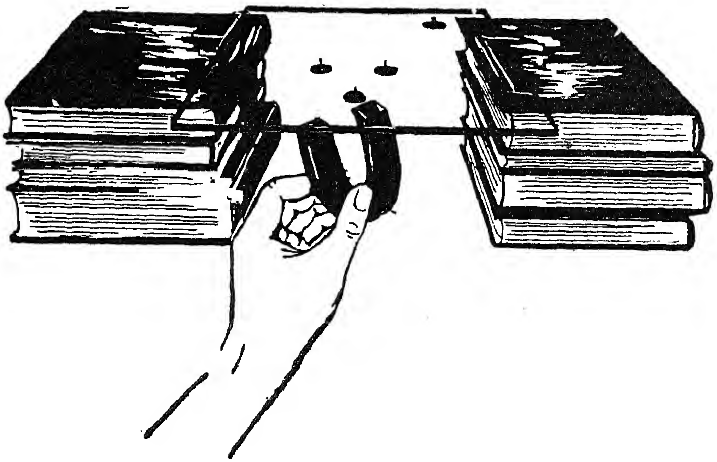


Fig. VI.37. What will magnetism pass through ?

Major Concept 4. Magnets may be made from steel.

Concept 4-a (p. 59) : This may be done by tapping vigorously a piece of steel in a magnetic field.

1. A steel needle, a hack saw blade, a file or any other piece of steel can be magnetized by tapping it in a magnetic field. This may be done by holding the north and south ends of two bar magnets in one hand and hitting the two ends of the piece of steel on the north and south poles of the two magnets simultaneously (See Fig.VI.38 a).

2. Bar magnets which have lost their magnetism maybe re-magnetized by holding the north and south ends of the two weak magnets in one hand as above, and simultaneously hitting the other ends on the two poles of a very 'strong' magnet.

3. A steel needle can also be magnetized by stroking it on a magnet. Repeat this several

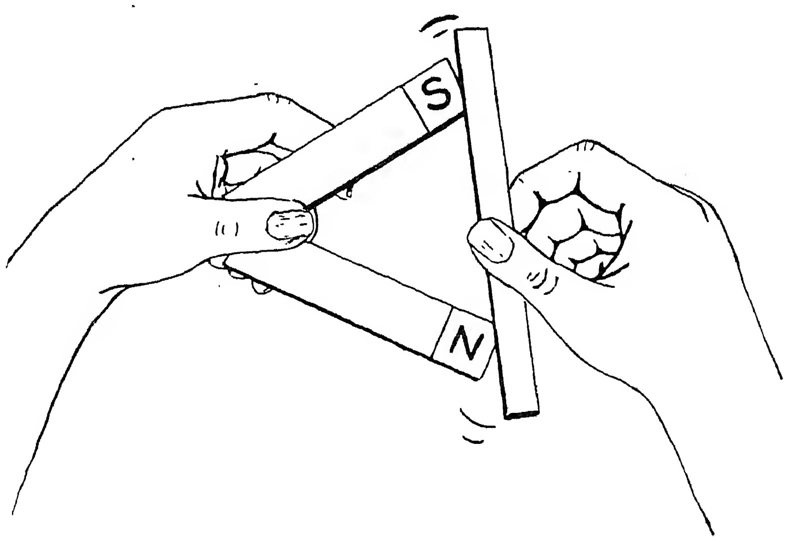


Fig. VI.38a. Magnetizing a piece of steel by tapping in a magnetic field.

times on one end of the magnet, as shown in Fig. VI. 38 b. Now stroke the other end of the magnet with the other end of the needle.

4. Hold a steel rod in the north-south direction. Strike the rod several sharp blows in this position and now test it with a compass to see whether it is magnetized.

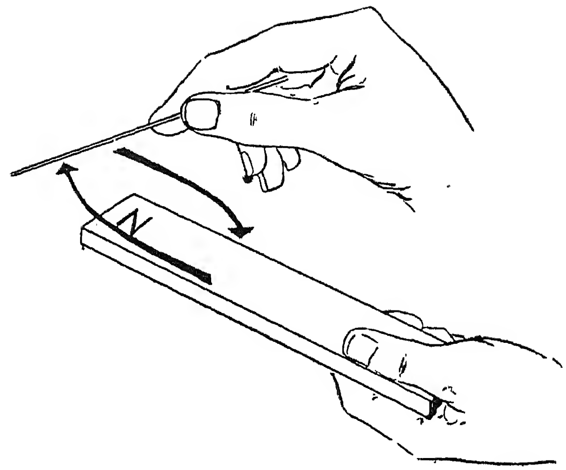
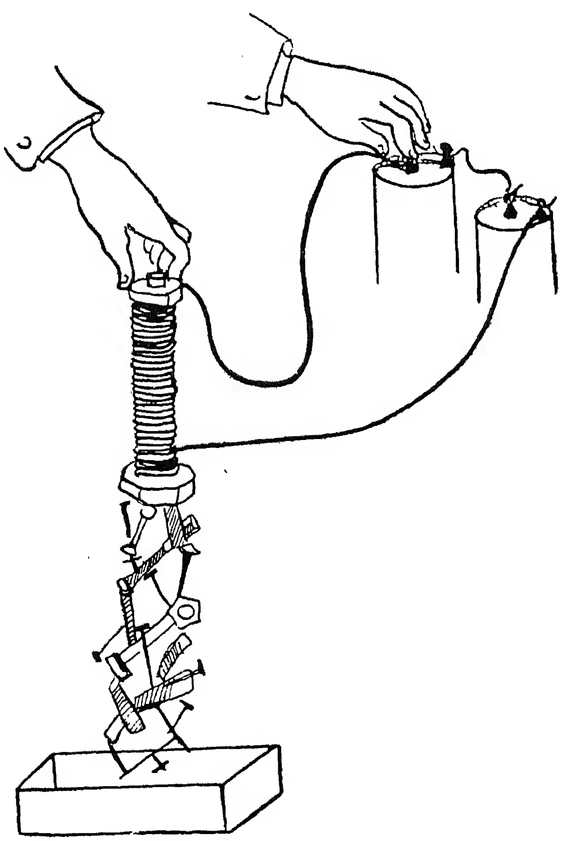


Fig. VI.38 b. Magnetizing a needle by stroking.

Concept 4-b (p. 59): Magnets may also be made by passing a current through an insulated wire coiled round a piece of iron or steel.



Take about 500 cm. of insulated wire and wind it neatly a number of times around a large iron nail or screw or a steel rod. Now connect the ends of the wire to a dry cell. See how many tacks or iron filings are picked up. The iron nail is now magnetized. When a coil of wire carrying an electric current contains an iron core, it is called an electromagnet. (If you pull out the iron nail, the coil of wire will also be a magnet. A coil of wire carrying an electric current acts as a magnet. When an iron core is present in the coil, its magnetic attraction is increased.)

Fig. VI.39. Making an electromagnet.

Major Concept 5. Magnets are useful to man in many ways.

Concept 5 a (p. 59): A magnet is used in a mariner's compass to find direction.

To see if it is magnetism that makes a compass needle point north:

(a) Test a compass to see if its needle does point towards the north. Then bring first one end and then the other end of a bar magnet near to the compass. Watch the compass needle spin.

(b) Does the magnet affect the direction of the needle? Do both ends of the magnet affect the needle in the same way?

2. You can make a floating compass by magnetizing a steel needle and (See Concept 4 a activity 3), pushing it through a small flat circular piece of cork. Float the cork (with the needle) in a shallow pan of water. You may also suspend the magnetized needle on a fine thread using a cardboard stirrup so that it will hang horizontally as shown in Fig. VI.40 c.

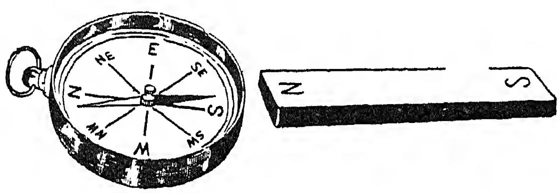


Fig. VI.40 a. The compass is a magnet.

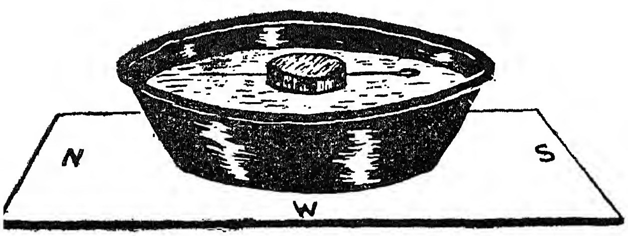


Fig. VI.40 b. A floating compass.

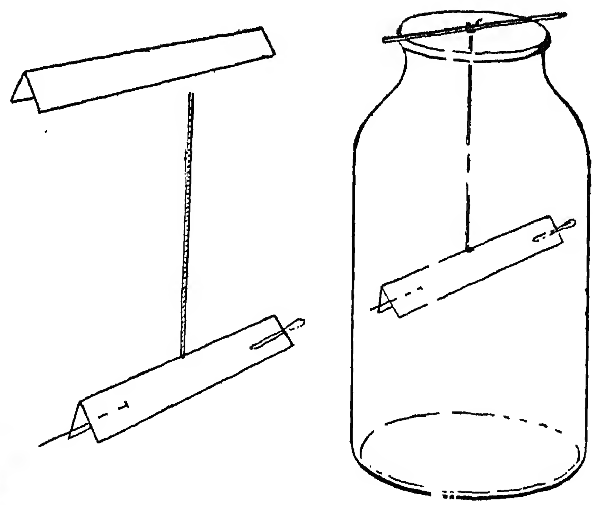


Fig. 40 c. A suspended compass.

Concept 5-b (p. 59): Magnets are used to detect electric currents.

To demonstrate that a magnet can be used to detect an electric current, bring a compass near a wire carrying a current. Note that the needle shifts its position when the current is turned on and off. If the wire is horizontal bring the compass needle below the wire and parallel to it.

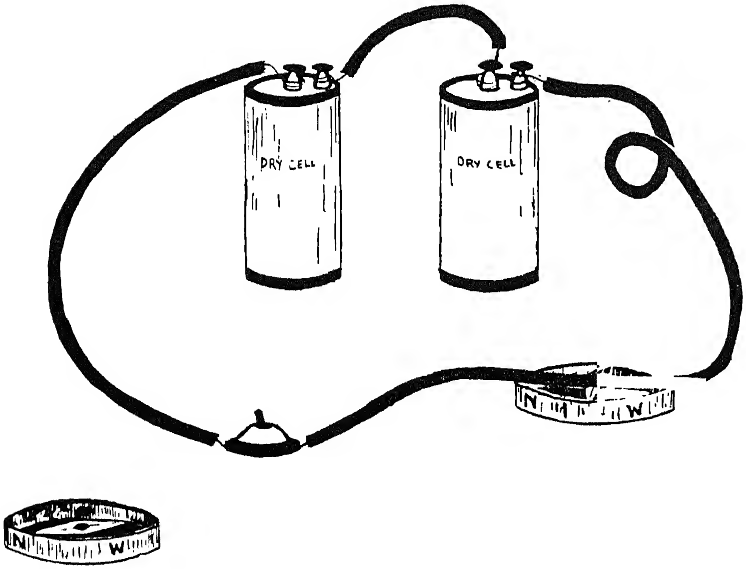


Fig. VI.41. Detecting an electric current with a magnet.

Concept 5-c (p. 59): Magnets are used to separate constituents of mixtures.

Mix some tacks and rice or wheat or sand. Separate the tacks from the mixture by passing a magnet through it, and lifting the tacks out.

Electricity

Major Concept 1. Electricity is of two kinds—positive and negative.

Concept 1-a,b (p. 59): (a) Atoms are composed of small parts called electrons (negative charges) and protons (positive charges) and neutrons (neutral particles). The protons and neutrons are clustered in the centre of the atom (nucleus) with the electrons moving about it.
(b) From some substances electrons or negative charges of electricity can be easily removed by rubbing.

1. Darken the room, stand before the mirror and comb your dry hair with a comb. Note the little sounds you hear on combing and the sparks that fly off. What makes the crackling sound? You have made electricity by the friction between the hair and the comb.

Rub the comb with a piece of wool cloth and bring it very near some fine pieces of paper, such as tissue paper. What happens to these pieces of paper? What causes them to stick to the comb?

Every object is made up of small parts called *atoms*. The atom is made up mostly of three types of particles, the *neutrons* (neutral particle) the *protons* (the positively charged particles) and the *electrons* (the negatively charged particles). The protons and neutrons are close together at the middle of the atom in a tiny bunch about one

thousandth the size of the atom. This bunch is called the *nucleus*. Every atom has a nucleus in the middle with electrons whirling around it.

The neutrons have about the same mass as the protons. These neutrons may be thought of as a combination of a positive charge of electricity, a proton, closely combined with a negative charge, an electron. The electrons move around the nucleus much as the planets move around the sun.

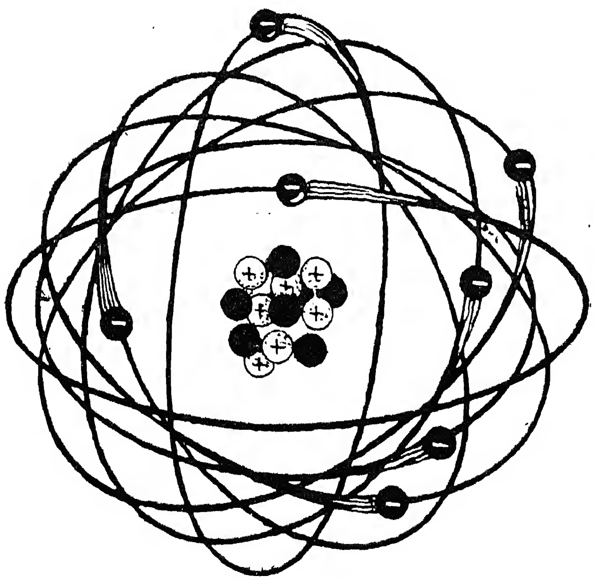


Fig. VI.42a. Protons and neutrons in the nucleus of an atom and electrons circling around it.

Every atom may be thought of as composed largely of electricity: the positive charges in the protons, the negative charges in the electrons, and a close association of positive and negative charges in the neutron.

Since an atom has an equal number of positive and negative charges, it is normally neutral. But we can account for the negative charges that accumulate on a comb rubbed through your hair by saying that some of the electrons of the atoms in your hair have rubbed off on the comb. Thus the hair becomes positively charged, for it has too few electrons, and the comb becomes negatively charged for it has too many electrons. The sparks occur when the excess electrons on the comb jump back to the positively charged hair. After the spark occurs, both the hair and the comb become neutral again.

Since every substance is made up of atoms and every atom has electrons, there is electricity in every thing around you—rugs, shoes, comb, hair, etc. Only you have to make the electrons move. You can make them move from one object to another by rubbing as you did when you rubbed your hair. The electrons from the hair moved to the comb and as they piled up there on the non-conductor they became a charge of *static electricity*. As the electrons pile up too much on the comb, they flow back to the hair. This flowing of electrons is called a spark or a *current* of electricity.

Major Concept 2. Electricity produced by rubbing is called frictional or static electricity.

Concept 2-a,b (p. 60):

(a) When a rod of rubber, sealing wax or plastic is rubbed with fur or wool the rod becomes negatively charged.

(b) When a rod of glass is rubbed with silk, the rod becomes positively charged.

Major Concept 3. Like charges repel, unlike charges attract.

Concept 3-a,b (p. 60): (a) In rubbing a glass rod with silk, the electrons leave the rod and remains on the silk, so the silk is negatively charged. The glass rod has fewer electrons and is positively charged.

(b) If a rubber or plastic rod is rubbed with fur, electrons from the fur rub off on the rubber making it negatively charged. In this case the fur has a positive charge.

1. Rub a glass rod, test tube or your fountain pen vigorously with some animal or plant fiber. A piece of chamois skin or soft leather would serve well. Bring the object close to some torn bits of tissue paper or pieces of thread or small pieces of cork. Do they cling to the object? Why? The rubbing has caused a charge of electricity to remain on the object. Charged objects attract neutral objects by sharing their protons or electrons. Electricity that is caused by rubbing or friction is called static or frictional electricity.

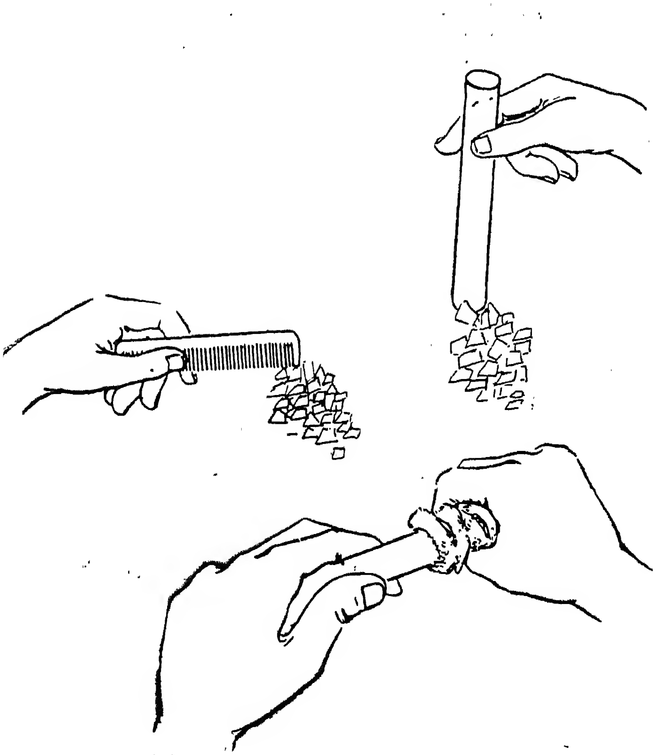


Fig. VI.42b. Electric charges attract bits of paper.

2. Hold two strips of paper as shown in the figure. Rub them by pulling two ends rapidly through your fingers. What happens?

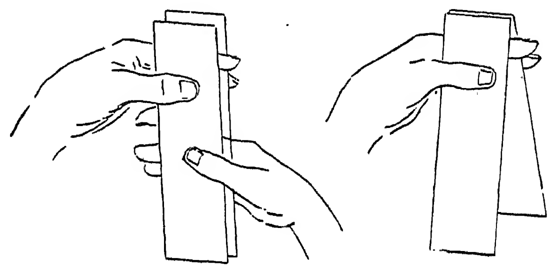


Fig. VI.42c. Charged strips of paper.

3. Hang two balloons by threads. Rub each balloon with wool. What happens?

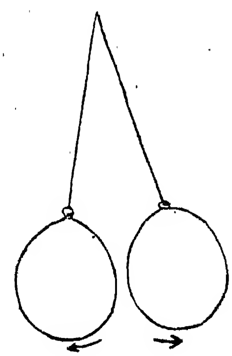


Fig. VI.42d. Charged balloons.

4. Make a little ball of tin foil. Suspend it by a silk thread. Charge a comb by rubbing it with wool. Bring the comb near the ball of tin foil. The charged comb pulls the ball towards it. But when the ball touches the comb, part of the charge in the comb goes into the ball. Now the ball has the same kind of charge as the comb.

The ball now moves away from the comb. Can you explain why?

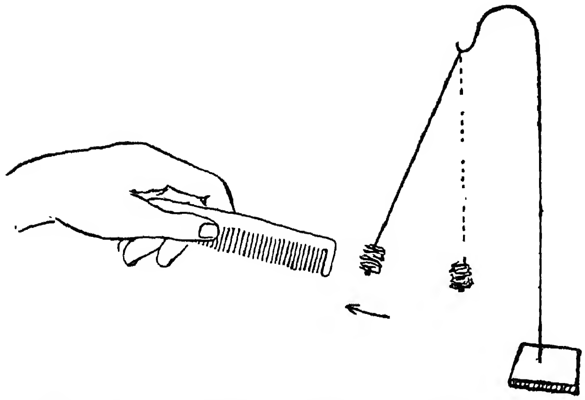


Fig. VI.42 e. Effect of charges on a metal foil ball.

5. Suspend a balloon by a thread and give it an electric charge by rubbing it with wool.

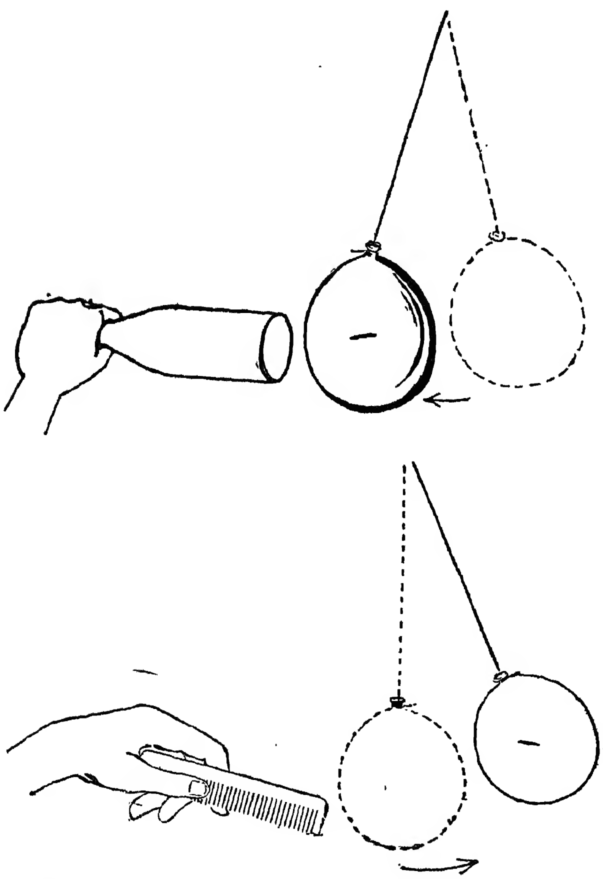


Fig. VI.42 f. Effect of unlike charges on a negatively charged balloon.

Rub a glass bottle with silk. Bring it near the balloon. What happens?

Rub a comb with wool. Bring it near the balloon. What happens? You know that both the bottle and the comb are charged but the two charges are not the same. (See Fig. VI. 42.)

6. Make a simple turntable in this way. Drill a hole and put a large nail or wire about 15 cm. long through a small piece of board. Secure a large cork about five centimeters in diameter and a test tube. Dig a hole carefully in the centre of the cork with a penknife, about the diameter of the test tube and nearly through the cork. Insert the closed end of the test tube firmly into the hole and invert it over the nail or wire. This will give you a turntable that will revolve easily. Set pins in the cork so that objects do not roll off. (See Fig. VI. 42g.)

Now charge a glass rod or a test tube and a comb. Place the test tube on the turntable and bring the comb near it. What do you notice?

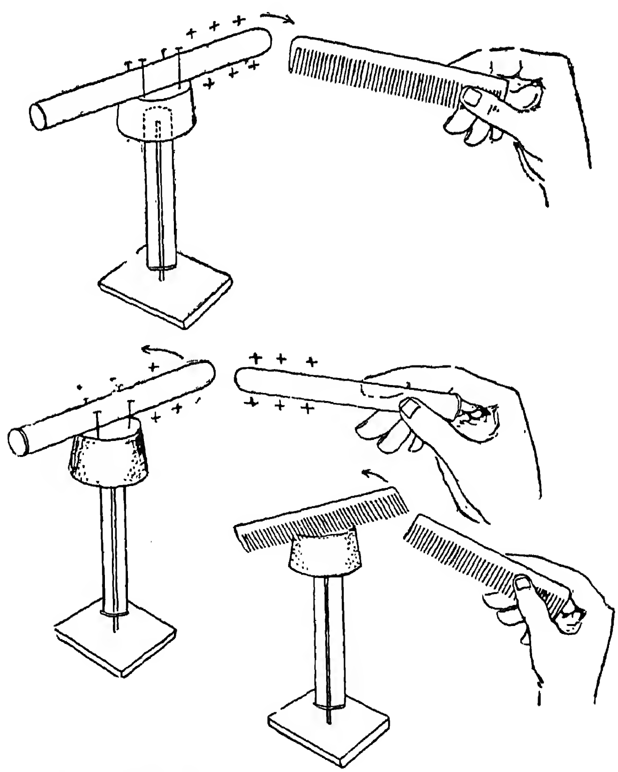


Fig. VI.42 g. Testing the effect of charges on a charged glass tube.

Bring another electrified glass rod near the turntable and test them. Repeat with two combs. In which of these cases do you notice that the objects attract, and in which do they repel?

7. Procure two peacock feathers and draw them quickly through a folded newspaper. The feathers should acquire a positive charge. Test the charge to see if it is positive or negative. Bring the two charged feathers close to each other and see how they affect each other. Account for what happens.

8. Rub different things with different kinds of cloth and test them. First test each to see if it is charged. (Notice if it picks up bits of paper.) Then bring each near a charged balloon. If it pushes away the balloon it has the same charge as that on rubber. If it attracts the balloon, it has the same kind of charge as that on glass.

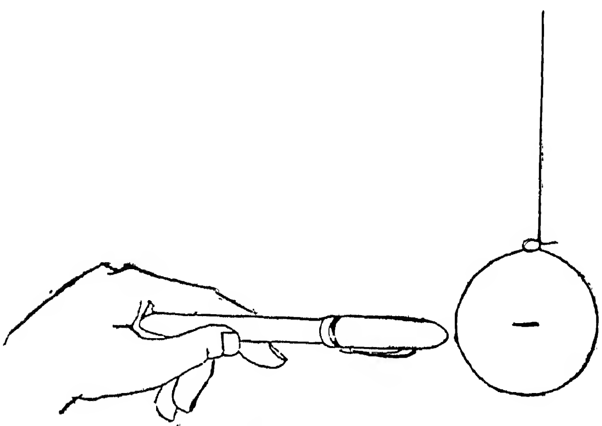


Fig. VI.42 h. Testing the effect of charges on a charged balloon.

Scientists who have experimented with electricity have found that there are two kinds of charges —positive and negative. One is the kind of charge on rubber that has been rubbed with wool. The other is the charge on glass that has been rubbed with silk.

When the rubber is rubbed with wool, some electrons are transferred from the wool to the rubber. The rubber thus gets an excessive charge of electrons and gets *negatively* charged. When the glass rod or test tube is rubbed with silk, some electrons are transferred from the glass to the silk. The glass thus loses electrons and becomes *positively* charged.

Thus you see that like electrical charges repel each other and unlike electrical charges attract each other.

9. An electroscope is a device to detect and measure *static electricity*.

You can make an electroscope by the following method.

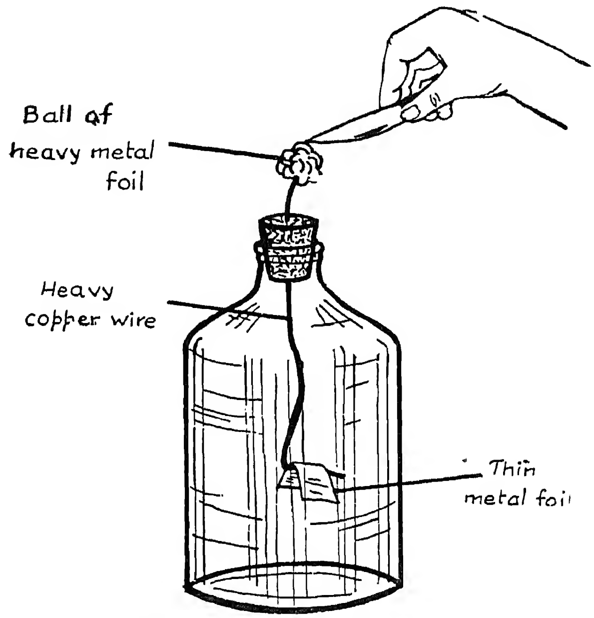


Fig. VI.42. How to make an electroscope.

Take foil from a gum wapper, some heavy copper wire, a jug, a cork, and a strip of heavy metal foil. Follow the diagram for assembling the materials. The heavy metal foil is pressed into a ball and pressed around the top of the copper wire. The electroscope works in the following manner. If you touch the top with a charged comb, electrons from the negatively charged comb stream down the copper wire onto the thin foil. The two ends of the thin foil draped over the bottom of the copper wire will spring apart since both become negatively charged.

Your electroscope can be used to determine unknown static charges. Bring your object with an unknown charge to touch the top terminal of the already charged electroscope. If the object with the unknown charge is negative, more electrons will be repelled away from the terminal

down to the aluminium foil. The pieces of foil will therefore spring apart from one another even more. On the other hand, if the object is positively charged, some of the negative charges from the leaves of the electroscope will be attracted toward the terminal, causing the leaves to come together slightly. They will come together since they will not be so strongly charged negatively.

To discharge the electroscope, merely touch the terminal with your finger.

Major Concept 4. An electric current is a stream of electrons flowing from a negatively charged body to a positively charged body.

Concept 4-a (p. 60): To make electricity flow there must be a complete path or a circuit, that is, a flow of electrons from an electrical source through a conductor, back to the source:

(i) The flow of electrons in a circuit may be set up or stopped by a device called *switch.*

(ii) Electricity flows along the path where there is least resistance. A short circuit may occur when the two wires going to an electrical device touch each other. Great heat may be produced causing fire.

(iii) A fuse is a safety device that melts when the temperature reaches a critical point.

For electricity to flow, there must be a complete path or a circuit, that is, a flow of electrons from an electrical source through a conductor, back to the source.

1. The flow of electrons in a circuit may be set up or stopped by a device called *switch*.

Rig up a circuit, using an insulated copper or aluminium wire with the insulation scraped off from the ends of the wire where you make the connections. Connect one end of one wire to the bell, and the other end to one of the terminals of a battery. Connect one end of a second wire to the switch and the other end to the second terminal of the battery. Connect one end of a third wire to the switch and the other end to the bell as is shown in the figure.

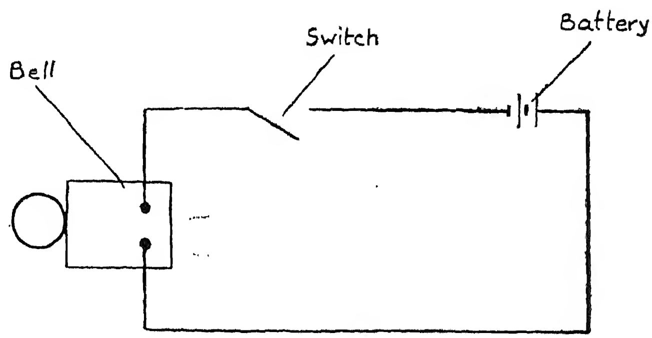


Fig. VI.43. Electron path in a circuit.

A complete circuit is a complete path for the flow of electricity. This complete path is called an open circuit when the switch is open and no current is flowing; it is called a closed circuit when the switch is closed and electricity is flowing. Close the switch and note by the ringing of the bell that electricity is flowing in the circuit.

A short circuit may occur when the two wires going to an electrical device touch. Considerable heat may be produced causing a fire. To see how short circuits occur, place short wires in parallel at several places in a complete circuit as shown in Fig. VI.44 (Caution: In doing this experiment hold the wires only momentarily or you will run down the battery.) Use a copper wire to make the different short circuits. Place a short wire across the terminals leading to the switch. Note that the bell rings continuously whether or not the switch is closed. Perhaps you have had a short circuit

like this in your automobile and it made the horn blow without stopping.

Place a short circuit across the terminals of the bell. Does the bell ring when you press the switch? Explain. Place a short wire across the terminals of the battery (hold it for just a moment). This is the type of short circuit that can set fires to buildings.

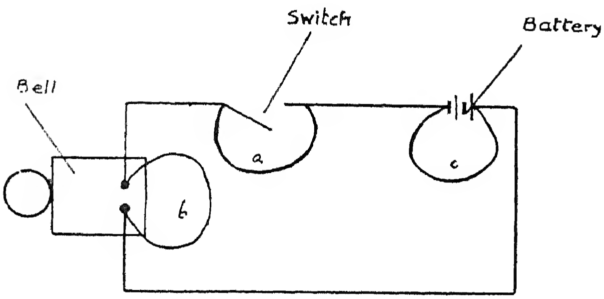


Fig. VI. 44. Short circuits. *a.* **across switch,** *b.* **across bell,** *c.* **across battery.**

3. A fuse is a safety device that melts when its temperature reaches a critical point.

To demonstrate how a fuse works to open a circuit, rig up a complete circuit as in (1) above, but this time insert a home-made fuse between the switch and the battery. Make the fuse with a narrow strip of tin foil about 2.5 cm. long. Then place a short circuit which includes the battery and the fuse as shown in the figure. The tin foil should melt, thereby stopping the flow of current in the short circuit. Also examine the house circuit fuses to find the wire that melts and stops the flow of current when a short circuit occurs.

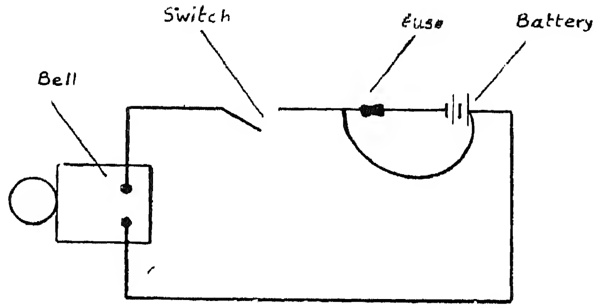


Fig. VI. 45. How a fuse works.

Concept 4-b (p. 60-61): Certain materials conduct electricity well, and others do not.

(i) A material that conducts electricity well is called a conductor; a material that does not is called an insulator or a non-conductor.

(ii) All metals are conductors of electricity. Silver is the best conductor. Being cheaper, copper and aluminium are more frequently used.

(iii) The most commonly used insulators are porcelain, rubber, plastic, paper, silk and certain types of enamel.

To see what materials conduct electricity, connect a circuit like that shown in Fig. VI.46.

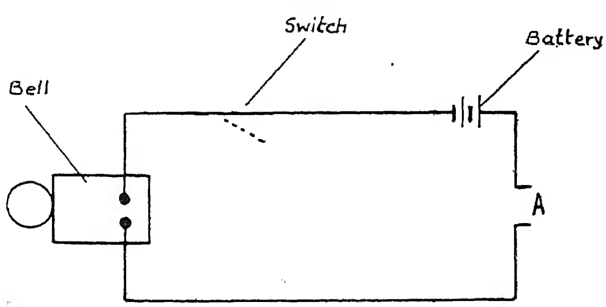


Fig. VI. 46. Testing electrical conductors.

Try placing a different material across the gap in the circuit at A. If the material does not conduct electricity, the bell will not ring. Try iron, copper, wood, rubber, glass, nickel, silver, aluminium, etc. Which is the best conductor of electricity? Classify materials as conductors and non-conductors of electricity. A conductor is a material through which an electric charge is readily transferred. An insulator is a material through which an electric charge cannot be readily transferred. Good insulators are poor conductors. Observe the different kinds of materials that are used as insulators. Glass, mica, paraffin, hard rubber, bakelite, sulphur, silk and many plastics are good insulators.

Major Concept 5. Two common methods of wiring circuits are (i) in series, and (ii) in parallel.

Concept 5-a (p. 61): In a series circuit, the current flows through each of the devices. There is only one pathway for the electricity to move along. If any one of the devices goes out of action, all the rest will stop working.

To show a series circuit, connect three dry cells as shown in Fig. VI.47 a.

Trace the current through them. Does the current which flows through one also flow through the other? Disconnect one dry cell and see what happens. Find out what advantage a parallel circuit has over a series circuit.

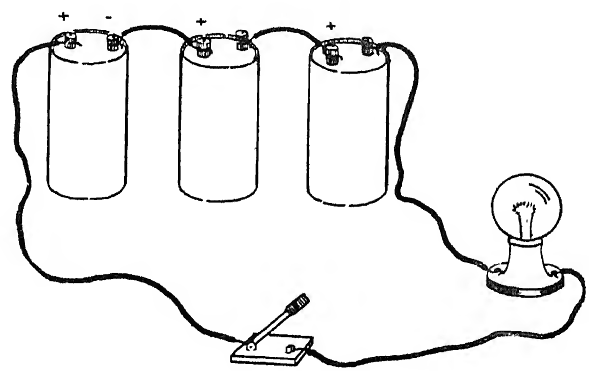


Fig. VI. 47a. A series circuit.

Concept 5-b (p. 61): In a parallel circuit the current flowing through one device does not flow through any other. There are several pathways for the electricity to move along. So each device wired in parallel can be turned on and off independently.

Connect three dry cells in parallel as shown in Fig. VI.47 b.

Trace the current. Does the current which goes through one also go through the others? Disconnect one dry cell. What happens to your light?

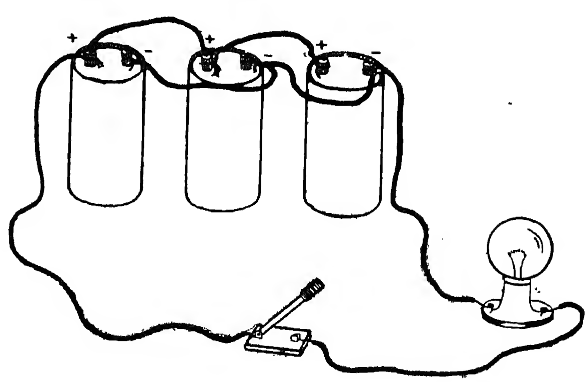


Fig. VI.47 b. Parallel circuit.

Major Concept 6. Electricity may be produced in several ways.

Concept 6-a (p. 61): Static charges are produced when certain materials are rubbed together.

1. See activities under Major Concepts 1 and 2.

Try rubbing several kinds of materials to see if you can charge them. Are the materials you charge electrical insulators or conductors?

2. Charge the hard rubber plate of an electrophorus (Fig. VI.48) by rubbing it vigorously with cat's fur. Then place the metal electrophorus plate on hard rubber. Touch the top of the metal plate with a finger, and then remove the plate with the handle. Bring the edge of the plate near your hand. Is there a spark? Knowing that like electrical charges repel and that unlike charges attract, explain what happens when you touch the plate with your finger when it is on the charged rubber plate. Then explain what happens as you remove the eletrophorus plate from the rubber plate. Explain what happens when you touch the edge of the plate.

3. To make an electrophorus you will need a candle, a short glass or plastic rod, a flat metal disc like the top of a can, an old phonograph record (breakable type) and a piece of wool or fur.

Fasten the glass rod to the metal disc with a bit of candle wax. Now rub the phonograph record with the wool or fur. Using the rod as a handle, touch the record with the metal disc. Now touch the disc with your finger for an instant. Raise the metal disc by the handle and touch your nose with it.

In this activity the disc becomes positively charged in the following manner:

A strong negative charge is built up on the record due to the rubbing action. When the metallic disc is placed on the record, and you touch the top of the metallic disc with your finger, electrons are repelled and they run off the disc to the ground through your finger. Thus a positive charge is left on the metallic disc.

If your metallic disc is perfectly flat, this device will allow you to build up a higher electrostatic charge than by rubbing combs, paper or fountain pens.

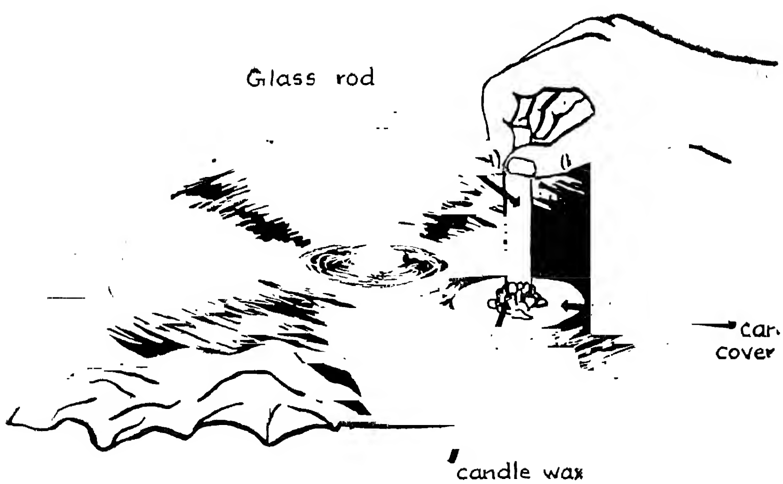


Fig. VI.48. Home made electrophorus.

Concept 6-b (p. 61): In an electrical cell, a current is produced by the action of a chemical on two unlike metals or other material.

Take apart some worn out dry cells to see how they are made. The carbon rod serves as positive pole and the zinc can as the negative pole. Just inside the zinc can you find a moist paper wet with a solution of ammonium chloride.

The current is generated by the action of the ammonium chloride on the zinc. When the chlorine ions from the ammonium chloride combine with the zinc, a white powder called zinc chloride is produced.

Concept 6-c (p. 61): In a generator, an electric current is produced from mechanical motion by the relative motion between a magnet and a coil of wire.

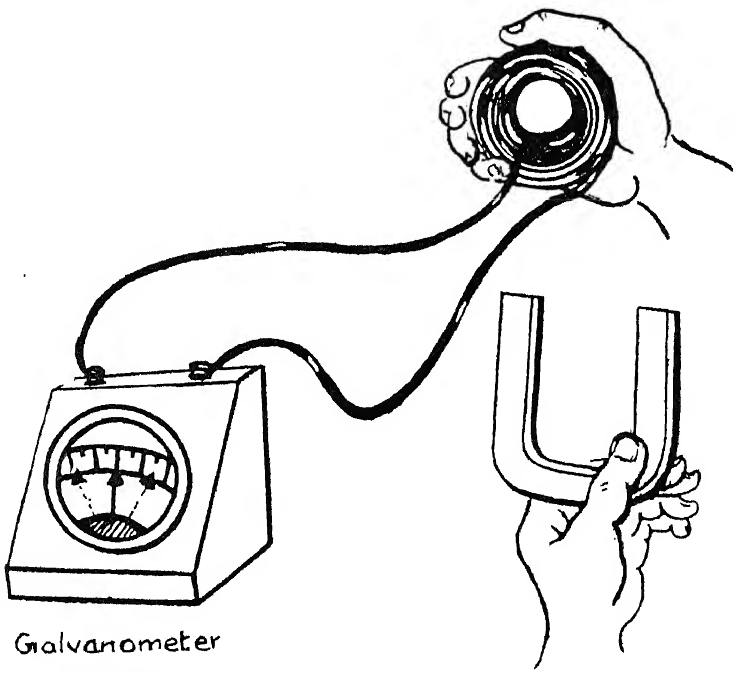


Fig. VI.49. An electric current is produced by moving the magnet through the coil.

1. To show how a magnet may be used to produce electricity, move one pole of a bar or U-magnet through a coil of wire connected to a galvanometer. Does the needle move when the pole of the magnet is held still in the coil? Compare the direction in which the needle moves when you push the north pole into the coil and when you pull it out of the coil. Compare the movement of the needle when you use a north pole and when you use a south pole. Do you get the same result when you hold the magnet still and move the coil? How can you increase the flow of electricity? What energy is converted into electricity?

2. To show two other ways in which the flow of electricity may be increased, (a) use two magnets instead of one, thereby increasing the magnetic fields, and compare with the electricity produced when using one magnet; (b) substitute a coil with more turns of wire and compare with the smaller coil.

3. To see how a magneto or a generator works, turn the armature of a magneto connected to a light bulb. Disconnect the bulb and see how easy it is to turn the generator. Then connect the bulb and see how hard it is to turn it. Account for the difference. What energy is converted into electrical energy in a magneto or a generator? (mechanical energy.)

Concept 6-d (p. 61): Solar cells convert light energy into electrical energy.

To demonstrate that solar cells generate an electrical current, show the action of a light meter (exposure meter) such as is used in taking a photograph. The indicator hand is moved by an electrical current which is made from the light energy striking the solar cell. (Refer to Fig. VI.10).

Concept 6-e (p. 61): The thermocouple converts heat energy into electrical energy.

To demonstrate that electricity may be generated from heat, make a themocouple and connect it to a galvanometer as shown in the figure. Take a piece of iron or nichrome wire about 1 metre long, and two pieces of copper wire. Snap the ends of the wire clean and twist the copper wires to the iron or nichrome wire as shown. Heat one of the junctions on a bunsen flame and coil the other end in ice water. Observe if a current flows through the galvanometer.

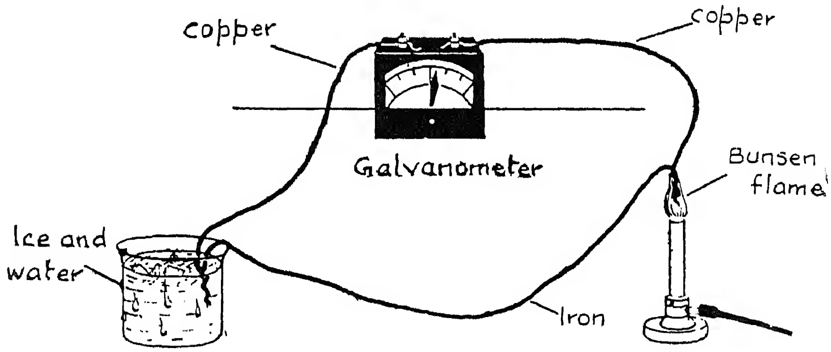


Fig. VI.50. A thermocouple.

Major Concept 7. The electromagnet is a device used to change electrical energy into mechanical energy.

Concept 7-a (p. 61): A wire carrying an electric current has a magnetic field about it.

Pass a wire vertically through a piece of paper and connect the circuit so that a current may pass through the wire. Sprinkle iron filings on the paper, turn on the current and tap the paper lightly with a pencil as the current flows through the wire. Observe the iron filings lining up in circles around the wire. If you rotate a compass around the wire, you will observe the needle moving in a circle as the current flows through the wire. Reverse the direction of the current flowing in the wire and see what effect, this has on the direction of the compass needle.

Concept 7-b (p. 62): An electromagnet is made by winding a wire in a coil about a piece of iron and passing a current through the wire. It can be made stronger by adding more coils of wire or by passing more current in the coils. Its poles can be reversed by changing the direction of the current flowing in the coil of wire.

1. To make an electromagnet, wrap many turns of an insulated wire around a soft iron bolt. There should be from 25 to 100 turns of wire. Number 18 copper or aluminium wire works well. The insulation may be enamel, plastic or rubber. (Fig. VI.39.)

2. To see how this electromagnet works, connect a dry cell to it and see if the magnet will pick up paper clips. Release the circuit. What happens? (Caution: Do not keep the magnet connected to the dry cell long, for it will run down the dry cell.)

3. To see how an electro-magnet can be made to attract more, connect two dry cells in series with the magnet you have made. Compare the number of paper clips it picks up when connected to one cell with the number it picks up when connected to two cells.

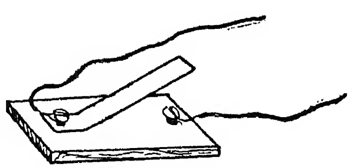
Make a second electro-magnet with more turns of wire than those on the first. Connect this larger electromagnet to one cell and compare the amount it picks up with the amount the small electro-magnet picked up when connected to one dry cell. In what two ways may the attraction of electro-magnets be increased.

4. To find out how to reverse the poles of an electromagnet, bring a pole of one electromagnet near a compass needle and identify it as being a north or south pole. Then change the connections on the dry cell so that the current flows through the electromagnet in the opposite direction. Test to see if the poles are the same. How does one reverse the poles of an electromagnet?

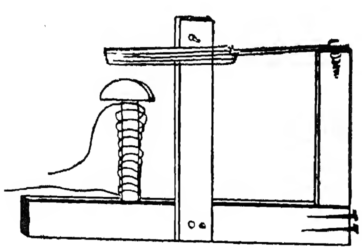
Concept 7-c (p. 62): Electromagnets are used to move things, as in an electric telegraph, an electric bell, a telephone receiver, a loud speaker and an electric motor.

1. To show how electromagnets are used to move the armature of a telegraph, construct and operate a simple telegraph set. Make a key from a strip of metal from a tin can, two wood screws, a wooden base and two insulated wires as shown in Fig. VI.51a.

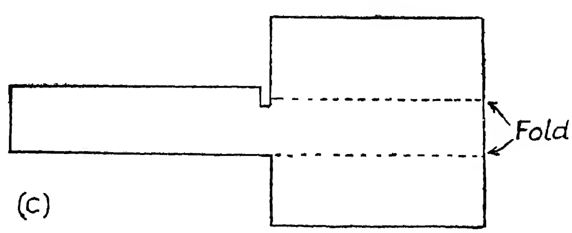
Make a sounder like the one shown in (b). Make the electromagnet from insulated wires (No. 14) copper or aluminium by winding over a carriage bolt. Nail three pieces of wood together as shown. Make an armature from a piece of metal cut from a tin can as shown in (c). Fold the sides over to make a rigid armature. Screw or



(a)



(b)



(c)

Fig. VI.51 a,b,c. Parts of telegraph set.

nail the flexible end to the top of the end upright wooden piece. Bend the metal up the base. Then drive a nail in the side of the upright piece to keep the armature from moving too far from the electromagnet. The two ends of the electromagnet wire may be connected to terminals for convenience in connecting into a circuit.

To demonstrate how the telegraph works, connect the telegraph key and the sounder in series with one or two dry cells.

2. To make an electric buzzer, make two electromagnets about 5 c.m. long, an armature from the metal in a tin can, and mount these as shown on a wooden base about 10 c.m. wide and 25 c.m. long as shown in Fig. VI. 52 (A).

Use two thicknesses of metal bent at right angles to anchor the electromagnets. To make an armature cut a piece of tin can metal. Fold the armature end to make it stiff. Cut a piece of the armature for a circuit breaker, as shown in (B).

To see how an electric bell works, connect an electric bell as shown in the figure.

When you close the switch note that the bell rings. What pulls the armature towards the bell? What pulls the armature away from the bell? What keeps the armature moving towards the bell after the current is opened in the circuit?

3. To see how a telephone receiver is constructed, take one apart and note the electromagnets in it. Note also that the diaphragm is made of a thin sheet of steel that springs easily. Note that coils of wire are wound on a permanent magnet rather than on a piece of soft iron. What is the advantage of making this a combined permanent and electromagnet?

To test this telephone receiver, connect the wires from it in series with a dry cell and a machinist's file as shown in the figure. Close the circuit alternately by rubbing the end of one of the wires over the rough file. You should hear a noise as the current goes on and off as you move the wire along the file.

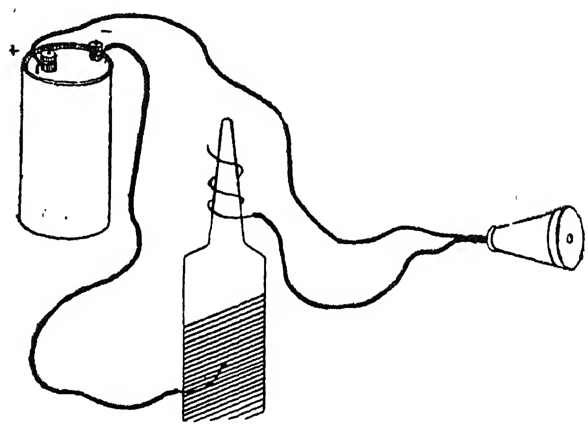


Fig. VI.53. How sound waves are produced in a telephone receiver.

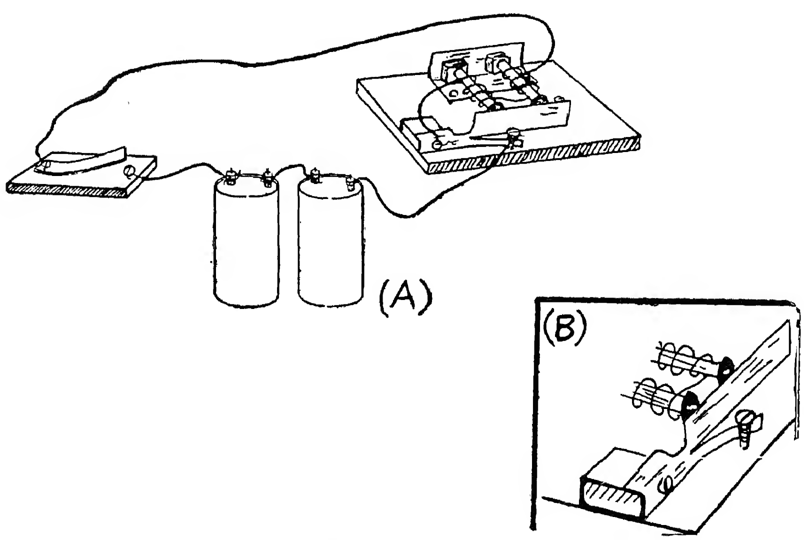


Fig. VI.52. Electric buzzer.

4. To demonstrate how the transmitter of a telephone varies the electric current to make it match the sound waves, connect two carbon rods from an old cell in series with a dry cell and an ammeter (the kind used to test dry cells with). Press the two rods together lightly and note that some current flows in the wire. Then press the carbon rods together tightly and notice that more current flows in the wire. In the transmitter there are particles of carbon that are compressed tightly and loosely by the sound waves created when one talks into the telephone. In this way the amount of current flowing through the receiver is varied. The electromagnet in the receiver moves the metal disc in the receiver in such a way that it reproduces faithfully the sound spoken into the transmitter.

5. Examine a loud speaker, an electric motor and other electrical equipment to see how electromagnets are used to move things.

LIGHT—A FORM OF ENERGY

Major Concept 1. We see things either because they give off light or because they reflect light received from some other source.

Concept 1-a,b (**p. 62**) : (a) The sun, the star, lamps and fires are seen by the light they produce.
(b) The sun is the source of most of our light.

1. Ask if anyone has tried to see the objects inside a closed room at night. Why is it necessary to light a candle, lamp or an electric bulb for the purpose? What will be the result if the source of light is put off? What will happen if the windows and doors of the room are opened and no source of light is present in the room?

2. Demonstrate that light is necessary if one is to see an object in a box. To do this, take a large cardboard box. An empty shoe box or one from the general merchants' shop will do. Pierce a small hole in the cover. Cut a large hole of about 5 sq. cm. at one side of the box. Blacken the inside of the box. Place some small things in the box and replace the cover. Cover up the square hole by placing a thick black sheet of paper, twice as large as the hole, pressed against the box. Try to see things in the box through the top hole. Can you see things in the box? Uncover the square hole and again look into the box. What do you notice?

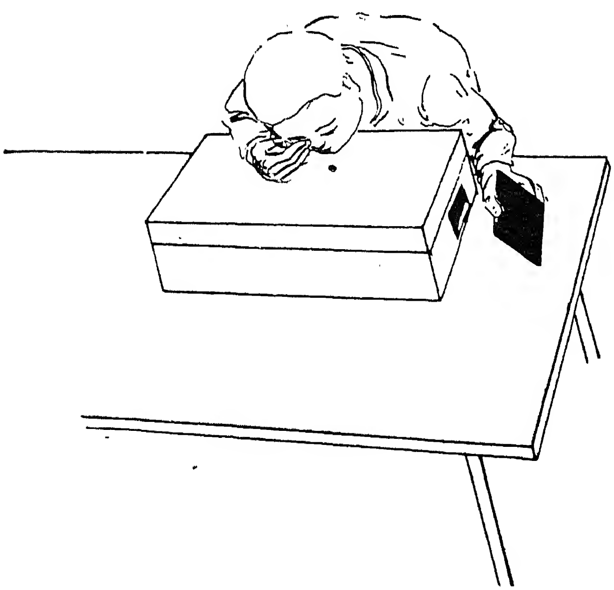


Fig.VI.54. Light is necessary to see objects.

3. You cannot see if there is no light. In the day the sun sends light; at night you use lighted candles, lamps, or electric bulbs to see things. Anything that sends out light is called a 'source' of light. Almost all the sources of light are hot. Those which are not hot are very uncommon. Glow worms give off a cold light. Many marine plants and animals glow. There is yet another type of source of light. Radium, a radio-active material, gives off alpha and beta particles, and gamma rays which are all similar to X-rays. When these rays strike some materials like zinc sulphide they cause these materials to glow. The luminous parts of a watch or time-piece dial are coated with a mixture of radium salts and zinc sulphide and so produce light.

4. You see things because light either comes from them or is reflected by them to our eyes. In the daytime sunlight falls on objects and from those objects the light comes to your eye and you can see the objects. You use artificial sources of light in a room at night. Light from a lamp falls on things in the room and then comes from things to your eyes. You 'see' when light comes or is reflected from things to your eyes.

5. Can you see things in the dark? You do not see the black printing in the books, but you see the white paper round the letters and so know their shapes.

6. Can you see a beam of light? Light is given off by a source of light. From the various things it strikes, it is reflected to your eyes. You see the things, but not the light. A beam of light that you appear to see in a dusty room is not the beam of light itself. You see only those particles of dust which are lit up by the beam of light.

7. The sun, the stars, lamps and fires give off light. They are called *luminous bodies*. They become visible by the light they give off. Objects such as buildings, trees, grass, furniture, or the pages of a book are non-luminous. They are visible only when they receive light from some luminous source and reflect it to your eyes. A body may be luminous or non-luminous depending as much on its condition as on the material of which it is made. By changing conditions you can make some of the common substances luminous or non-luminous as you wish. (The filament inside an electric bulb is non-luminous unless it is heated by an electric current.)

Is the moon which you see at night, a luminous or a non-luminous body? Explain how you see the moon.

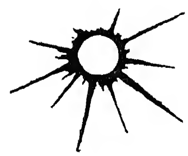
8. What makes the difference in light at daytime and night, or on a cloudy day and a bright day ?

Which source of light illuminates the moon?

At early dawn, objects that you could not see a few minutes earlier, begin to take shape. After some time the details become visible, colours appear and brighten. All this difference is made by the sun that you see rising above the horizon in the east. Most of your light comes from the sun and a little part of it comes from the rest of the stars.

9. Why does the sun appear very much brighter than any other star? The sun is about 93 million miles away from the earth, but much closer to it than any other of the billions of stars in the sky. The sun, even at that great distance, looks very bright to the eye. It is 5,000 times brighter than the dazzling brightness of molten steel and brighter than 450,000 moons. That is why you must never look directly at the sun without a smoked glass or an over-exposed photographic film.

Hold an over-exposed photographic film (if you do not have one, you can get one from a photographer) or a smoked glass between your eyes and the sun. What do you notice?



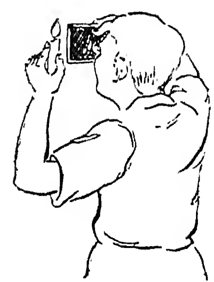


Fig. VI.55. Seeing sun through exposed film.

Next hold a lighted candle directly between your eyes and the sun, still using the exposed film. Can you see the candle flame?

Major Concept 2. Light is a form of energy which travels in all directions from its source.

Concept 2-a (p. 62): Most objects do not produce light. We see buildings, plants and many other things by the light they reflect.

For developing the concept that light travels in all directions from its source, do the following experiments in a room with its windows and doors partially shut to make it semi-dark.

Take two pieces of white cardboard and fix each to a piece of wood or any other support so that you can stand them upright. Make a pinhole in the middle of one of them and stand this card about 15 cms. from a source of light like a lighted candle or an electric bulb. Observe the other card (screen). What do you notice? (An inverted picture of the source.) You will be interested to know that a pin-hole camera works like this. Try constructing one.

Next make the hole a little bigger. Observe the screen. What do you notice? (The picture becomes brighter but is no more clear.) Make the hole bigger still. What do you observe now? (The picture is not clear at all.)

Take away the card with the hole. Do you still see the picture? What has happened to the part of the light from the source which was reaching the screen through the hole? (The parts of the screen other than those which received light through the hole are also receiving it now.)

Stand the screen on the other side of the candle. What do you notice? (The screen is bright all over at all positions as every part of the source sends light to every part of the screen.)

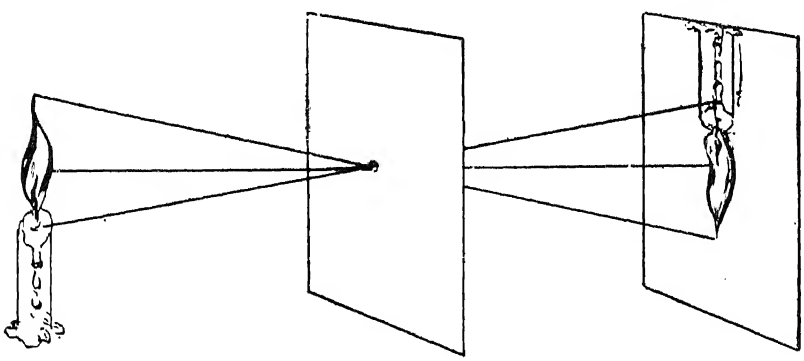


Fig. VI.56. Image through a pinhole.

Concept 2-b (p. 62): A light in the centre of a room will light the walls of a small room more brightly than it will light the walls of a large room.

In the previous experiment bring the screen near the source of light and move it away from it. What do you observe?

Concept 2-c (p. 62): Light travels in straight lines.

Ordinary common-day experience suggests that light travels in straight lines. Whenever you reach for an object you are confident that the object is just where you see it. You can do the

following experiments to find out for yourself that light travels in straight lines.

1. Hold a small piece of cardboard, about 5 sq. cm. in front of one eye. Close the other eye. Now look towards a large source of light like a lighted electric bulb, or a distant object like a tree. Can you see the object? What happens to the light coming towards your eye from the object?

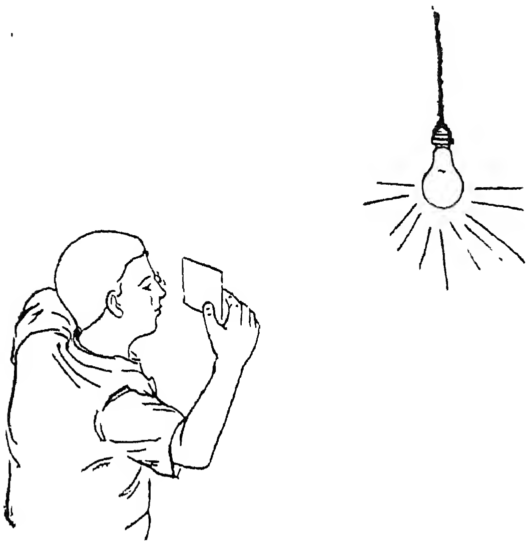


Fig. VI.57. The way light travels.

2. Darken a small room with a window facing the shining sun. Cover up the window with thick black paper using drawing pins. Cut three fine rectangular slits about 2 cm. in length and half a cm. in width. Dust a chalk-filled duster in the path of the light entering through the slits. Can you see the tiny particles of chalk illuminated by the light through the slits?

Observe the three beams of light that now stand out clearly. What is the shape of the beams?

3. Punch a hole in the middle of each of six large cards. Light a candle. Stand the cards an inch apart in such a way that you can see the light of the candle by looking through the hole in the card farthest from the candle. Move any of the cards out of the line. Can you see the light now? What does this experiment show you about the way light travels?

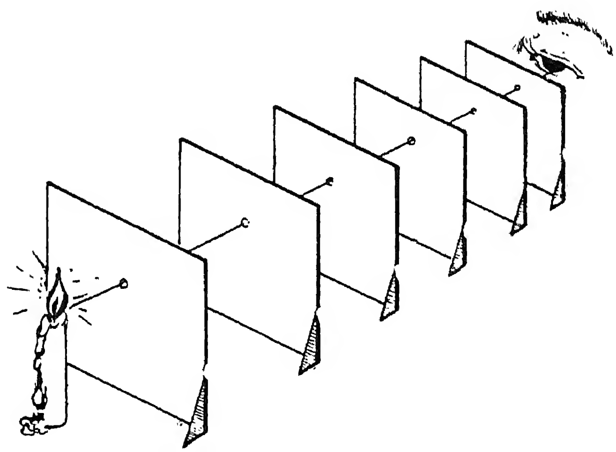


Fig. VI.58. Light travels in straight lines.

4. Observe the solar and lunar eclipses. Read in the newspapers when to observe them. Find out how they are caused.

Concept 2-d (p. 62): The intensity of light varies inversely as the square of the distance from its source.

To show that light varies inversely as the square of the distance, arrange a simple photometer and five similar candles. Place one candle at 30 cm. distance from the photometer and four candles at 60 cm. from the photometer as shown in Fig. VI. 59. To make the photometer, cut a hole about an inch in diameter in a piece of white cardboard; then put a piece of white thin paper over one side of the cardboard. Place the cardboard between the candles as shown in the diagram. (This must be done in a dark room.) When the paper in front of the hole appears equally bright with that around the hole, the light reaching each side of the cardboard is equal. Note how the brightness of the centre of the cardboard varies as you move it nearer and further away from the candle. Why is this so? (See Fig. VI.59.)

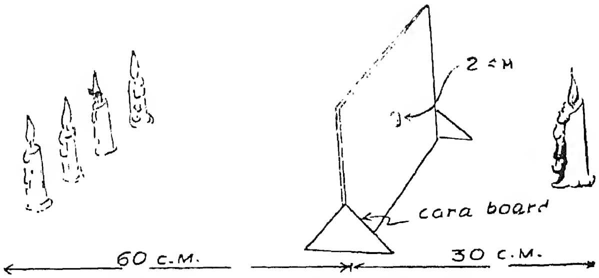


Fig. VI.59. How does distance affect light intensity?

Since the light reaching the cardboard in the position shown is equal on both sides, only $\frac{1}{4}$ as much light from each of the four candles reaches the cardboard as does from the single candle. Thus when one candle is twice as far away from an object as another candle, only one fourth as much light is received by the object, so that the intensity of light received varies inversely as the square of the distance from the object.

Concept 2-e (p. 62): Since the surface area of a sphere varies directly as the square of the radius, the intensity of light falling on the inside walls of hollow spheres from a light placed at the centre of these spheres will vary inversely as the square of the radii.

As is shown in Fig. VI.59, the inverse square law regarding the intensity of light, namely, that the intensity of light falling on an object varies inversely as the square of the distance of the object from the source of light, is essentially a spatial relationship. Light goes out from a source in all directions. Thus it may be thought of as travelling from the source along the radii of hollow spheres. The surface area of any sphere varies as the square of the length of the radii of that sphere. Thus all of the light that would fall on the inside of a small hollow sphere, will be spread much more thinly if spread out over the inside of a much larger hollow sphere. If the radius of the outer sphere is twice the radius of the inner sphere, the surface area of the outer sphere will be four times the surface area of the inner sphere and the intensity of light will be 1/4th that of the inner sphere. If the radius of the outer sphere is three times that of the inner sphere, then the surface area of the outer sphere will be nine times that of the inner sphere and the intensity of light falling on the outer sphere will be 1/9th that of the inner sphere. We unconsciously apply our familiarity with this law when we sit close to a reading lamp rather than across the room at a distance, whenever doing careful work or when reading.

This inverse square law, which expresses a spatial relationship, applies in many other matters as well. For example, the attraction of gravity varies inversely as the square of the distance from the attracting force. Electrical charges attract or repel with a force which is inversely proportional to the square of the distance between the charges. Keep alert for this relationship. You will find it again and again in the above cases and also in other cases.

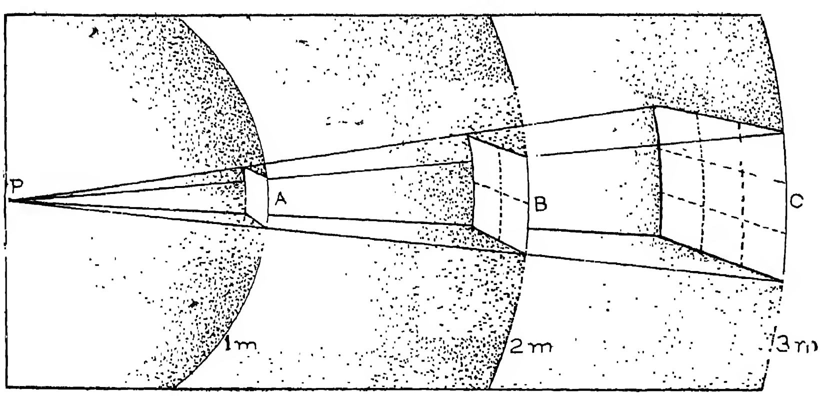


Fig. VI.59. The inverse square law is a spatial relationship.

Major Concept 3. Substances may be transparent, translucent or opaque.

Concept 3-a, b, c (p. 63): (a) Substances through which objects can be seen clearly are said to be 'transparent.'
(b) Materials through which we cannot see but through which some light passes are called 'translucent'; for example, etched glass.
(c) Materials through which light cannot pass are called 'opaque.'

The light given out by a source may strike substance like glass through which it can pass, or substances like stone or wood through which it cannot pass. Substances through which light can pass are said to be *transparent*. Those substances through which light cannot pass are said to be *opaque*.

What happens to the light which strikes on opaque substances?

Two things may happen to the light; some of it may be thrown off in all directions, but some of it may be taken in and lost. Opaque substances like metals throw off most of the light which strikes them and shine brightly. On the other hand an opaque substance which is perfectly black takes in all the light which strikes it and throws off none.

You can see through transparent substances like glass, a thin layer of water, and air. But there are some substances like etched glass, coloured glass or greased paper, through which you either cannot see or see only faint impressions of objects. They scatter the light that strikes and passes through them. Such substances are called *translucent*.

Identify by testing as many transparent and translucent substances as you can.

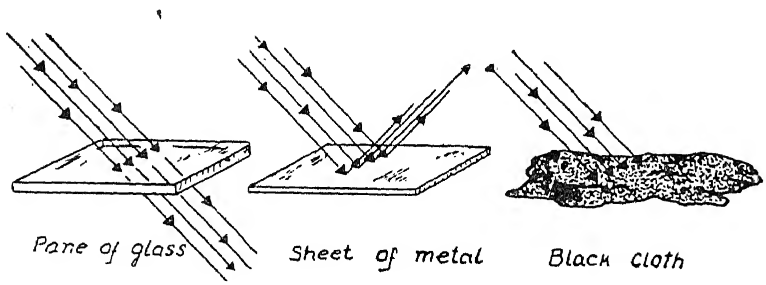


Fig. VI.60. Light may pass through, be reflected from or be absorbed by the substances it strikes.

Major Concept 4. An opaque body held in front of a source of light casts a shadow.

Concept 4-a,b (p. 63): (a) When the source of light is small (a point), the shadow cast is of uniform darkness.
(b) When the source of light is big, the shadow cast consists of a central region of complete darkness known as the 'umbra,' surrounded by a region of partial darkness called the 'penumbra.'

You know that shadows are formed by opaque bodies and you see them in daily life. To study about shadows do the following experiment.

Hold a piece of cardboard, or any other

opaque object, at a short distance from a lighted candle, and stand a white flat wooden screen on the other side of the piece of card. Observe the screen. What do you notice?

Use other pieces of card cut in different shapes and notice their shadows on the screen, one by one.

Next try a piece each of a thin transparent and translucent substance. Can you get a shadow using them?

Hold your hand between a source of light like a lamp and a piece of paper (screen) about 25 to 50 cm. away. Observe the shadow. What do you notice about the edges of the hand? (The edges are not sharp and clear.)

Stand a thin white card screen and an opaque object such as a small ball, in front of a lighted candle in a dark room. Have the candle light come through a small hole to achieve a pin point of light. Observe the shadow on the screen. Do you notice a dark shadow? Is there any lighter part at the edges?

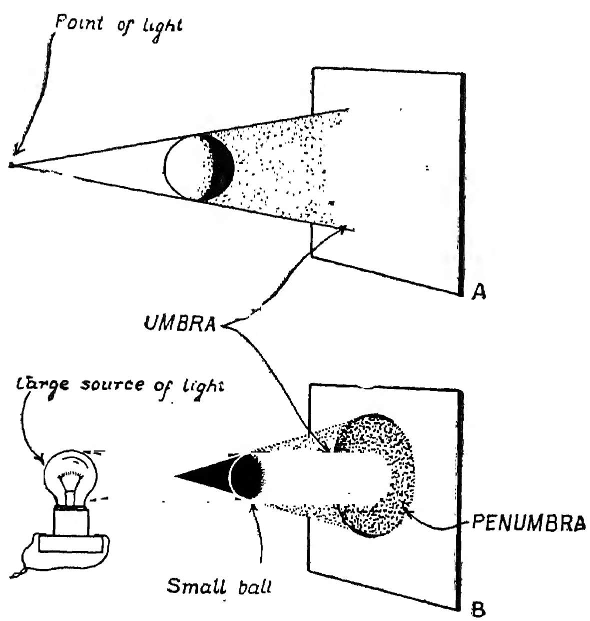


Fig. VI.61. Shadows, umbra and penumbra.

Make a little hole in the screen where the dark part of the shadow appears, without disturbing the arrangement. Look through the hole from behind. Can you see the candle? (No light comes to this part of the screen.) Now move the screen and look through the hole at the place where the less dark shadow appears. Can you see any portion of the candle now? This part of the screen receives light from only one part of the candle.

Next look through a hole just outside the edge of the shadow. Can you see the candle?

Now instead of using a pin point of light use a larger source of light such as a lamp. Have a lamp bulb larger than your small opaque object. Observe the shadow. Do you notice any difference in the shadow on the screen as compared to that received with a tiny source of light?

The dark part of the shadow in the middle which receives no light is called *umbra* (the latin word for shadow). The edges of the shadow which are less dark and receive light from one side of the source, but not from the whole of the source, are called *penumbra* (*pene* in Latin means almost). The penumbra makes the edges of the shadow less clear.

You can study shadows in further detail by observing the shadows of a pencil with a large source like a lamp which will be wider than the object. Obtain the shadow of the pencil on a screen placed behind the object and move the screen slowly away from the object. Observe the changes in the shadow. Do you notice that after a certain stage, the shadow becomes very large but not fully dark anywhere? Try to draw a diagram to help you understand what you observe. It would be somewhat like that in Fig. VI.61.

Collect data from an encylopaedia on the sun, the earth and the moon and try to understand the shadows which these heavenly bodies make at the time of eclipses.

Major Concept 5. Mirrors and other shiny smooth surfaces reflect images, while dull rough surfaces do not.

Concept 5-a,b,c,d (p. 63): (a) When a ray of light is reflected from a surface, the angle of incidence is equal to the angle of reflection.
(b) The reflection from a smooth surface (of an opaque body) is called regular reflection, for the reflected rays have the same pattern as the rays of light approaching the surface.
(c) The reflection from a rough surface is called irregular reflection, for the reflected rays are without any order.
(d) Mirrors may be plane, concave or convex—according to whether the reflecting surface is plane or curved.

1. Fit panes of window glass on the top and in front of a wooden or a strong cardboard box about 30 cm. wide and 60 cm. long. Leave the back open and cover it with loosely hung black cloth which drapes like a curtain. Hang this curtain in two sections making about a 10 cm. overlap at the middle of the box. Paint all the wood surfaces inside the box dull black.

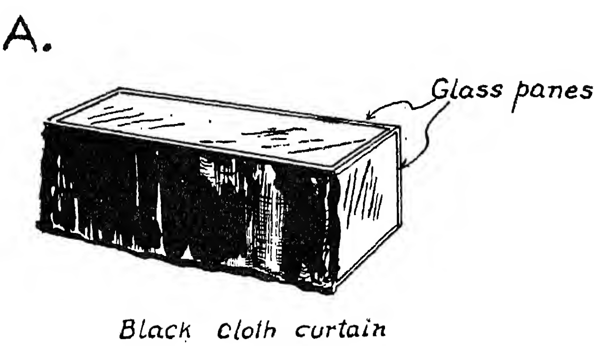


Fig. VI.62a. Smoke box for studying light.

Cut a window 5 cm. wide and 10 cm. long, and at one end about 8 cm. from the glass front. Cut an opening out of black paper to cover the window. In it make three equidistant holes about 5 mm. in diameter and fix the paper over the window with drawing pins. Next fill the box with smoke by placing a smouldering 'dhoop' or an incense candle in one corner of the box. Bring the flaps of the curtain back into position. Shine a strong parallel beam of light in front of the three holes by supporting a hand torch about one metre from the window. Observe the light rays in the box.

Place a plane mirror in the path of the light rays inside the box. Notice the rays after they strike the mirror. Place your eye directly over the reflected beam. Compare the glare of the two beams. (You will note a glare almost as bright as if you looked directly into the beam from the hand torch.) (Fig. VI.62 B.) Conclude that smooth surface reflects light without scattering it or diminishing its brightness.

To observe how a roughened surface reflects light, attach with rubber hands a roughened piece of clear cellophane to the mirror and place it in the path of light rays in the smoke box as done earlier for the mirror. You can make a rough surface by rubbing a sheet of clear cellophane with fine sand. (Fig. VI.62 a,c.) Notice the reflected rays of light. Are they clearly defined as in the case of the mirror? (They are completely mixed up and scattered.) Place the eye directly in the reflected glow and compare it with the bright glare of the regular reflection you had earlier observed with the mirror. Do you conclude that a rough reflecting surface diffuses the light?

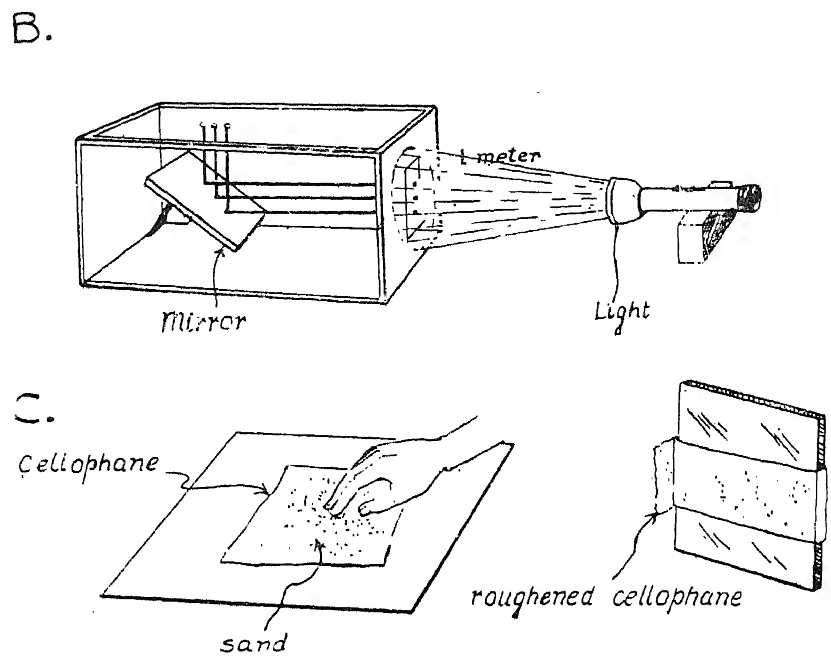


Fig. VI.62 b. Demonstrating regular reflection with a smoke box.
c. Making a roughened surface.

Discuss the application of the results of the experiments by linking them with day-to-day situations. Discuss when and why it is desirable to use dull shades for lamps and electric lights instead of smooth shining shades.

It is the regularity of reflection from smooth surfaces that results in the formation of images.

Recollect any landscape image you may have seen in still and clear water (or show such a photograph.)

2. To find out what happens when images are formed, look at yourself in a mirror. Is the view that you get of your image exactly like the view that others get of you? Move your left hand and in response, notice the hand movement in the mirror. Does your image move left hand or right hand? Place an object such as a pencil against the mirror and hold a similar pencil in your hand. Observe the images. Where does the image of the pencil in your hand seem to be? (Behind the mirror.) Compare the two images in apparent size, and relate the difference in sizes with the distance between your hand and the mirror by varying the distance.

3. On a piece of white cardboard draw a vertical line in the middle. Draw other lines making angles of 30°, 45° and 60° with the line in the middle at its lower end, and on both the sides of it. Support this card in an upright position on a plain surface like the top of a table, and place a mirror in front of it. Direct a strong, narrow beam of light from a torch light along one of the lines on the card. To get a narrow beam, cover the glass of the torch light with a black paper in which has been cut a thin sharp slit. Observe the beam striking the mirror. Notice the direction along which the beam gets reflected by the mirror. (It will be reflected along a corresponding line on the opposite side of the vertical line in the middle.) Repeat directing the beam along other lines and notice the direction of the reflected beam in each case. Also direct the beam along the vertical line. What happens to the reflected beam in this case?

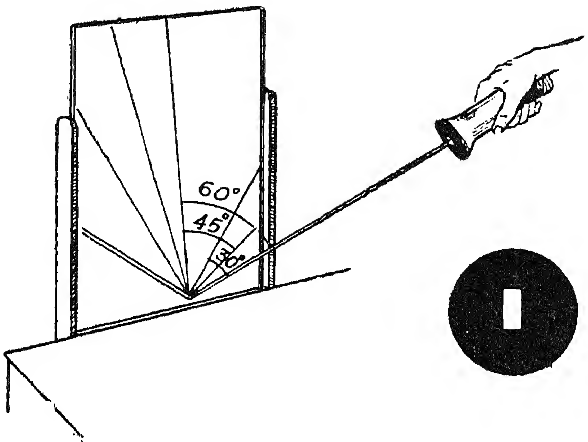


Fig. VI.63. Direction of light rays reflected in a mirror.

Next substitute a piece of white paper for the mirror, or put some chalk-dust on the mirror to make its surface rough. Direct a beam of light in various directions and try to observe the reflected beam of light in various directions in each case. What do you notice?

4. Relate the reflection of a beam of light to the bouncing of a rubber ball. You can bounce a ball on a smooth surface and note the angle between the striking direction of the ball and the surface of the floor to that between the bouncing back direction and the surface of the floor. Vary the striking direction of the ball and notice the angles in each case. Also throw the ball straight downwards and notice the way it bounces back. Can you anticipate the bouncing direction with confidence?

Repeat the bouncing on a rough surface like that of an uncemented brick-laid floor. Can you now anticipate the bouncing direction with confidence?

5. On a sheet of smooth white paper, draw a broken line in the middle using a ruler. Draw another straight line cutting it at any angle. Stand a small mirror upright at the point where the two lines meet. Turn the mirror until the reflection of the broken line is in line with the broken line on the paper. Look into the mirror and line up one edge of your ruler with the reflection of the line drawn in full on the paper. Record this direction by drawing a line along the edge of the ruler. Measure with a protractor the angles on each side of the broken line. Repeat this three or four times varying the angle between the broken and the full lines you draw. What is the relationship between the angle at which light strikes to the angle at which it is reflected by a mirror?

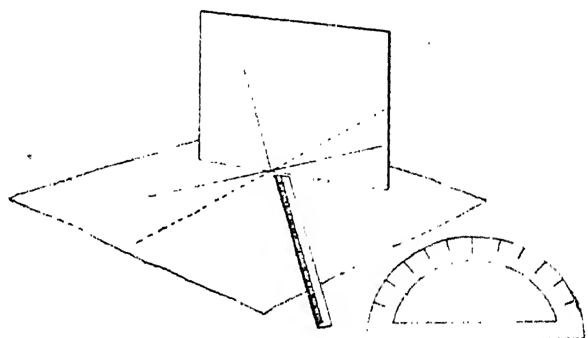


Fig. VI.64 b. Law of reflection.

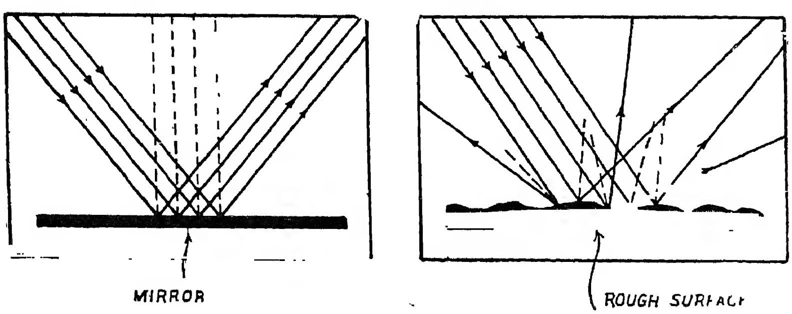


Fig. VI. 64 a. Reflection of light rays on smooth and rough surfaces.

Concept 5-d (p. 63): Mirrors may be plane, concave or convex—according to whether the reflecting surface is plane or curved.

Mirrors are used to reflect light. They are very smooth, highly polished surfaces capable of reflecting as much as 95 per cent of the light falling on them. The reflecting surface is usually formed by a coating of silver or aluminium paint, or of mercury on the back of a piece of glass of good quality. Some mirrors are also made of steel or some other metal polished to a very smooth surface. Reflecting surfaces of mirrors must be protected from scratches.

In addition to the plane mirrors you can sometimes find curved mirrors also in special use such as those used by medical practitioners for examining a patient's throat, or those used on vehicles to have a rear-view. These kinds of mirrors are called 'convex' or 'concave' mirrors depending or whether the reflecting surface is on the inside or the outside of the spherical surface. To differentiate between these two kinds of mirrors think of a convex mirror as the outside of a bowl having its outer surface polished; and a concave mirror as the inside of a bowl with its inner surface polished. The back side of a silver spoon is convex; the inside is concave.

Look into a concave and a convex mirror. Do you notice any difference in the images formed by the two spherical mirrors? Experiment with a large silver spoon and your own image. Observe mirrors on cars.

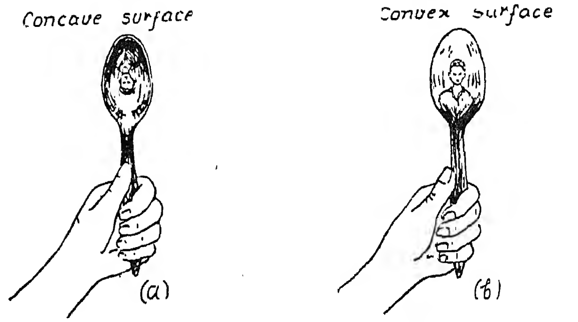


Fig. VI.65. Reflection from concave and convex surfaces.

Major Concept 6. When rays of light from a point appear to diverge from another point, or meet at another point after reflection, an image is formed.

Concept 6-a,b (pp. 63-64): (a) When an image is formed due to divergence of reflected rays from a point, it is called a virtual image. It cannot be seen on a screen.
(b) When an image is formed due to the convergence of reflected rays to a point, it is called a real image. It can be seen on a screen.

You can always locate the position of a point source of light if you know the direction of the rays coming from the source. You have simply to draw two or more of these backwards until they meet. The point where they meet is the position of the sources. When rays came to your eye from such a source, you automatically change the shape of the eye, and the diverging rays from the source are focused and you can see an image of the source. If the rays of light coming from an object have had their direction changed by reflection, you can trace the rays straight backwards and find their point of intersection. You can see the object, apparently located at this point, but this position need not be the actual position of the object.

Find out more about the images by studying the images formed by plain and spherical mirrors.

1. Stand a small mirror on a plain sheet of white paper. Fix a pin in front of it to serve as

an object. Look at the image of the pin as formed by the mirror. How is this image formed? Thousands of rays are sent by the object towards the mirror and are reflected according to the law of reflection. The reflected rays appear to come from behind the mirror and their line of intersection results in the formation of an image. You can trace the image by fixing four pins to get any two reflected rays and producing them behind the mirror by construction.

Can you obtain the image of the pin on a screen? Does it really exist? Observe the size of the image as compared to that of the object.

Draw what you observe.

The image formed by a flat or plain mirror is called a *virtual* image. The image seems to be behind the mirror. Actually a virtual image is not *real* because it only appears at the back of the mirror.

2. Stand in a room opposite a window or a door. Hold a concave mirror with its concave side facing the window. Reflect light from far away objects on a white opaque surface like that of a white card. Move the card back and forth until you get a clear image. Observe the image. Is the image right side up or upside down?

3. Look into a convex mirror. Observe your own image. Is it a real or virtual image ?

Major Concept 7. Regular reflection from mirrors may give rise to images of different nature.

Concept 7-a,b (p. 64): (a) In a concave mirror a parallel beam of light rays, after reflection, passes through a point in front of the mirror called the 'focus'. The distance of the mirror from the focus is called the 'focal length.'
(b) In a convex mirror a parallel beam of light rays appears to diverge from a point behind the mirror called its 'focus'. The distance of the 'focus' from the mirror is called the 'focal length'.

Spherical mirrors are used to reflect light.

A convex mirror reflects a parallel beam of light rays in such a way that the rays appear to be coming from a point behind the mirror called its *focus*. For each reflected ray the law of reflection holds, the normal at the point of incidence being the line joining the point with the centre of the spherical surface of which the mirror forms a part. The rays are said to be diverging after reflection from the mirror.

In the case of a concave mirror, a parallel beam of light rays reflected by the mirror are brought together at a point in front of the mirror called its focus. The law of reflection holds for each reflected ray, the normal at the point of incidence being the line joining the point with the centre

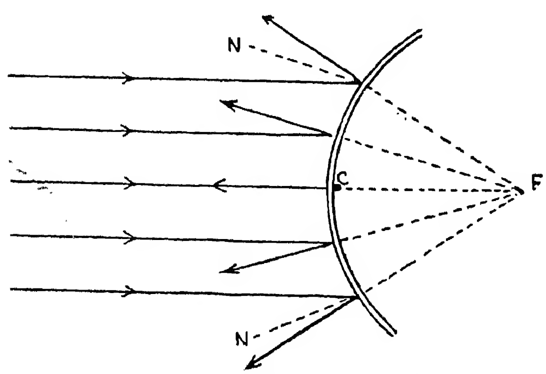


Fig. VI.66. Reflection in a convex mirror.
F=Focus FC=Focal length N=Normal

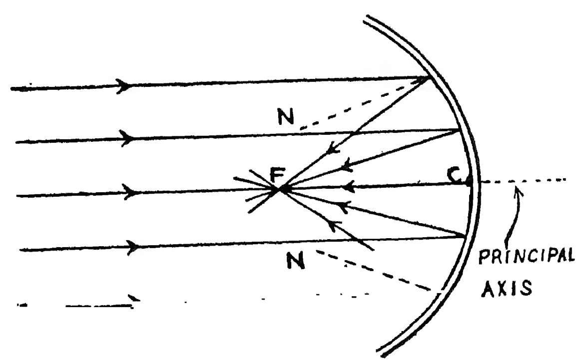


Fig. VI.67. Reflection in a concave mirror.
F=Focus FC=Focal length N=Normal

of the spherical surface of which the mirror forms a part. The rays are said to be converging to the focus after reflection from the mirror.

The shortest distance between the focus and the spherical mirror (concave or convex) is called its 'focal length.'

You can easily find the focal length of a concave mirror. Hold the mirror against sun's rays (which are always parallel coming from a far distant source of light). Stand a screen—a piece of cardboard with a white surface in front of the mirror and locate the position of the concave mirror to concentrate the reflected rays by moving the mirror towards or away from the screen. Measure the distance between the mirror and the screen. This distance is roughly the focal length of the mirror. Instead of using the sun's rays, you can also locate the sharp image of a far distant object like a tree or house.

Concept 7-c (p. 64): A plane mirror forms images which are virtual, erect and of the same size as the object, but are laterally inverted.

1. To show that the image in a plane mirror is laterally inverted, hold your right hand up in front of a mirror. Observe the reflection of the hand in the mirror. Does it appear to be your right hand or your left hand?

Print the words—BURN, LOW, POT, HOT—on four pieces of paper and hold them one by one in front of the mirror. Print the words as they appear in the mirror. Are the words laterally reversed in the image? Do some words look the same? Are the images you see in different cases smaller or larger, erect or inverted? Can you obtain these images on a screen?

2. To explore the position of an image in a plane mirror arrange a set-up in a darkened room as illustrated. Set a lighted candle at a distance of about 30 cm. from the front of the mirror. Observe the image of the candle in the glass either from the front or slightly to one side.

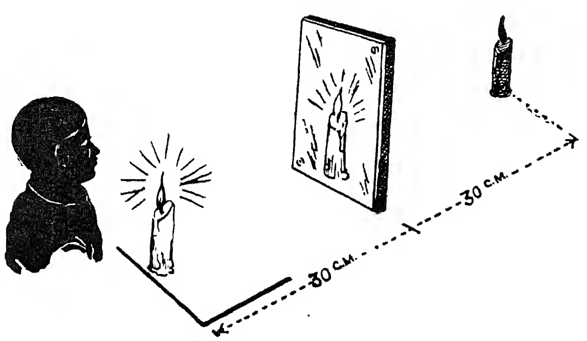


Fig. VI.68. Formation of an image in a plane mirror.

Place a second lighted candle in the apparent position of the image. Measure the distance from both candles to the mirror. Are these distances the same? Repeat this 3 or 4 times by changing the distance between the first candle and the mirror. Study the distances from both candles to the mirror in each case. What do you find?

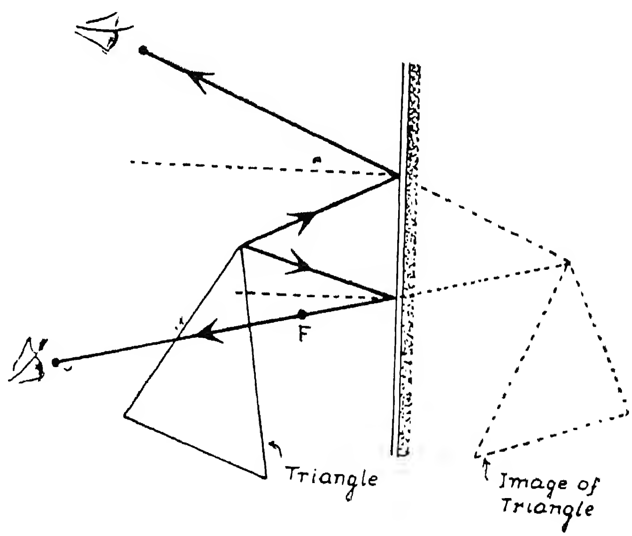


Fig. VI.69. A diagram showing the position of an image in a plane mirror.

The diagram shown in Fig. VI.69 shows a method by which you can construct the image of an object as formed by a plane mirror. Cut a triangle out of paper. This will serve as the object. Stand it in front of a mirror. Place a pin

at each vertex of the triangle and draw sight lines to locate the image. Notice that because the image is formed behind the mirror, it is reversed, the right side appearing as the left side. The image is neither enlarged or reduced but always erect, virtual and as far behind the mirror as the object is in front of it.

Concept 7-d (p. 64): A convex mirror always forms a virtual, erect and diminished image of a real object.

1. Stand in front of a convex mirror and look at your image. Is the image you see erect or inverted? Is the image smaller or bigger in size compared to your real size? Move away from the mirror. What happens to the image? Recall your experiences with the back side of the shiny spoon.

2. Try to focus on a screen the rays of the sun striking a convex mirror. Can you find a place where the rays seem to concentrate?

Concept 7-e,f (p. 64): (e) A concave mirror forms an enlarged erect and virtual image when the object is closer to the mirror than the focus.

(f) A concave mirror forms an inverted, real image when the object is farther from the mirror than the focus.

Measure the focal length of a concave mirror (as under 7-a, b). In a darkened room hold the concave mirror in front of a burning candle at a distance less than the focal length of the mirror. Is the image you see smaller or larger in size compared to that of the object? Is the image erect or inverted? Now place the candle at a distance greater than the focal length. Can you now obtain its image on a screen? Observe the image. Is it erect or inverted?

Next place the candle in front of the concave mirror at a distance equal to its focal length. Try to obtain the image on a screen. What do you observe? (No distinct image of the object is formed when the object is at a distance from the concave mirror equal to its focal length.) To form a real image the reflected rays must cross at some point, but in this case the rays of light are reflected from the surface parallel to each other. The diagrams below summarise the images formed by a concave mirror.

O = Object
I = Image
F = Focus of Concave mirror
M = Concave mirror

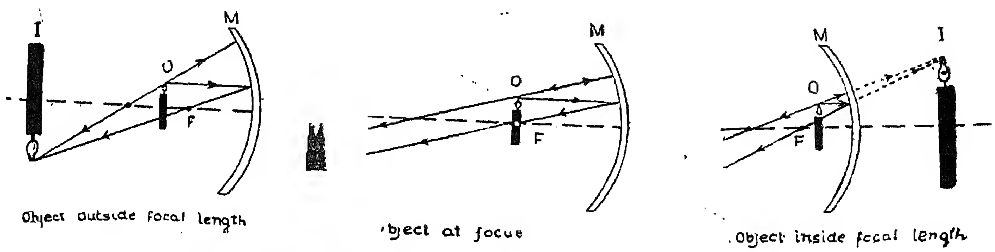


Fig. VI.70. Images formed by a concave mirror.

Major Concept 8. Mirrors are put to various uses.

Concept 8-a, b, c (p. 64) : (a) A plane mirror is used as a looking glass, to read type composed for printing, in a periscope and in certain sensitive scientific instruments such as a galvanometer.
(b) A concave mirror is used as a reflector in headlights, as a shaving mirror, in instruments used by a doctor or a dentist, and in projection apparatus.
(c) Convex mirrors are used as rear view mirrors in various types of vehicles.

Show optical instruments like periscope and kaleidoscope and observe the use of plane mirrors. Some would like to make model optical instruments using strips of plane mirrors.

Recall experiences like that of having looked into the rear view mirror on a vehicle or the reflectors in headlights. Review what has been learnt of reflection in curved mirrors. Explain the use of the concave mirror in the headlight; the convex in the rear view mirror. Relate other uses of spherical mirrors in instruments used by a doctor and in projection apparatus.

Prepare lists of the different uses of plane, concave and convex mirrors.

LIGHT-REFRACTION

Major Concept 9. The bending of a ray of light as it passes from one medium to another is called refraction.

Concept 9-a,b (p. 65) : (a) A ray of light passing from a rarer medium into a denser medium bends towards the normal (a perpendicular to the surface of contact of the two media).
(b) A ray of light passing from a denser medium into a rarer medium bends away from the normal.

A beam of light is bent while travelling from one transparent medium to another. The bending of light takes place as it goes from one medium to another because the speed of light is different in the different materials.

1. Place a coin at the bottom of a shallow opaque vessel like a cup. Move back from the vessel until its edge cuts off your vision of the coin. Ask your friend to pour water slowly into the cup, until you see the coin. What has enabled you to see the coin?

2. Place a stick in a glass trough filled three-fourths with water. Look down at the rod and then observe the rod through the side of the trough. What do you observe?

3. Place a coin at the bottom of a tall glass

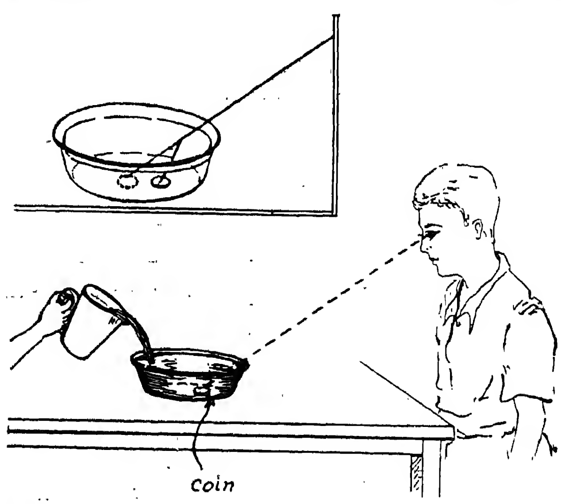


Fig. VI.71. A beam of light is bent in passing from one medium to another.

cylinder or jar filled with water. Look down into the cylinder and mark on the outside of the cylinder the apparent position of the coin. Compare the actual height of the coin from the surface of the water with the apparent height. What do you infer?

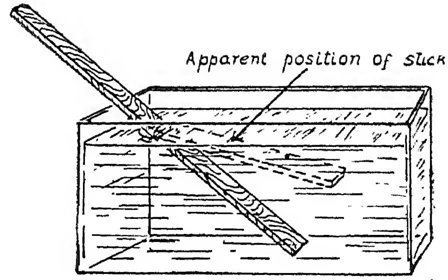


Fig. VI.72. Where do you see the stick?

Trace the path of a ray of light through a glass slab by fixing two pins A and B on one side of the slab placed on a sheet of paper (i). Look through the slab from the other face and fix another pin C so as to make the three pins appear in a straight line (ii). Fix pin D in the same way to make all the four pins appear in a straight line (ii). Mark the boundary of the slab and trace the path of incident ray through the glass slab and its emergence into the air (iii). Notice the bending of the ray of light when it enters the slab and when it emerges into air from the slab (iv). What do you conclude?

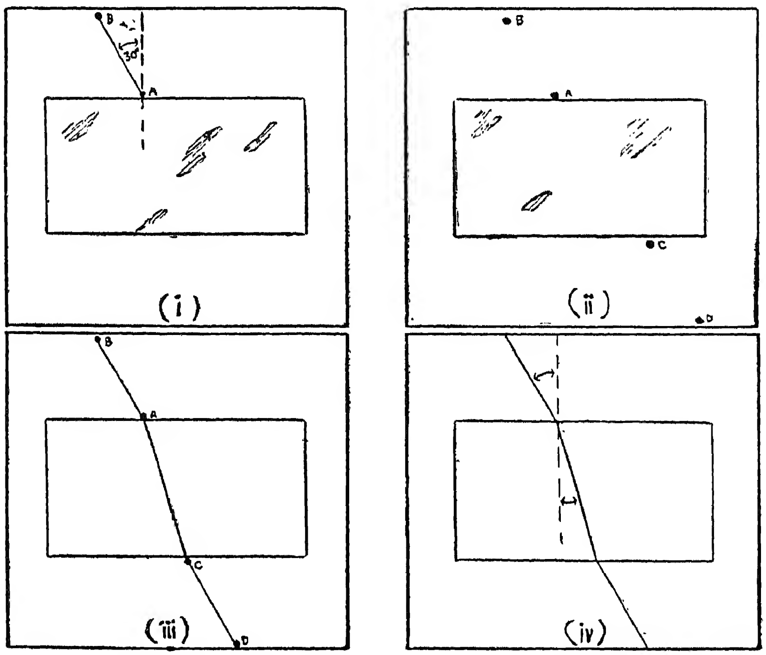


Fig. VI.73. Path of light rays through a glass slab.

Concept 9-c (p. 65): A ray of light passing through a prism bends towards the base as it enters the prism and as it leaves the prism.

Trace the path of a ray of light through a glass prism placed on a sheet of plain paper by fixing two pins 1 and 2 against the face A, B. Looking at them through the face C A, fix another two pins 3 and 4 as was done in the case of glass slab experiment above. The pins should appear to be in a straight line. Trace the path of the ray of light through the glass prism and out of the prism into air. What do you conclude regarding the bending of the ray of light when it enters the prism and when it leaves the prism?

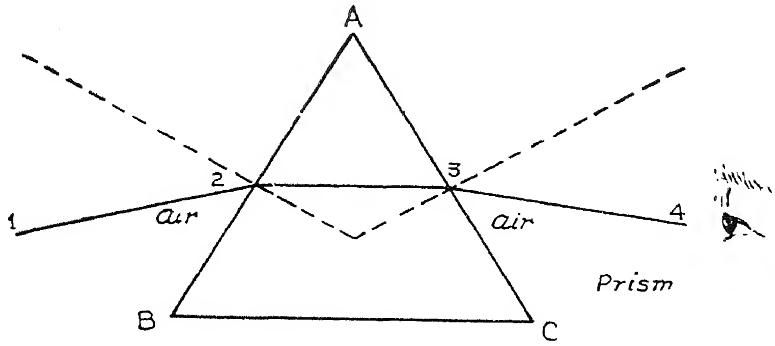


Fig. VI.74. Path of light ray throu

Concept 9-d (p. 65): Refraction causes many illusions.
(i) An object under water appears raised when seen from abov
(ii) A stick partially immersed in water appears bent.

The experiments in Concept 9 a, b, illustrate the illusions caused by refraction. Recall other experiences in your daily life such as aiming at a fish in a pond and looking through g on a rainy day, where refraction ma appear different than they are.

LIGHT-COLOUR

Major Concept 10. Sunlight is composed of light of different freq which we perceive as different colours.

Sunlight and uncoloured artificial light, either dark or reflected, is called 'white' or 'colourless light.' Under suitable conditions, white light can be spilt into a band of coloured light known as the *visible spectrum.*

To show that sunlight is composed of different colours, set a tray of water in brigh Place a rectangular mirror strip against edge and adjust it so that a visible appears on the wall or ceiling. H colours do you find in the spectrum?

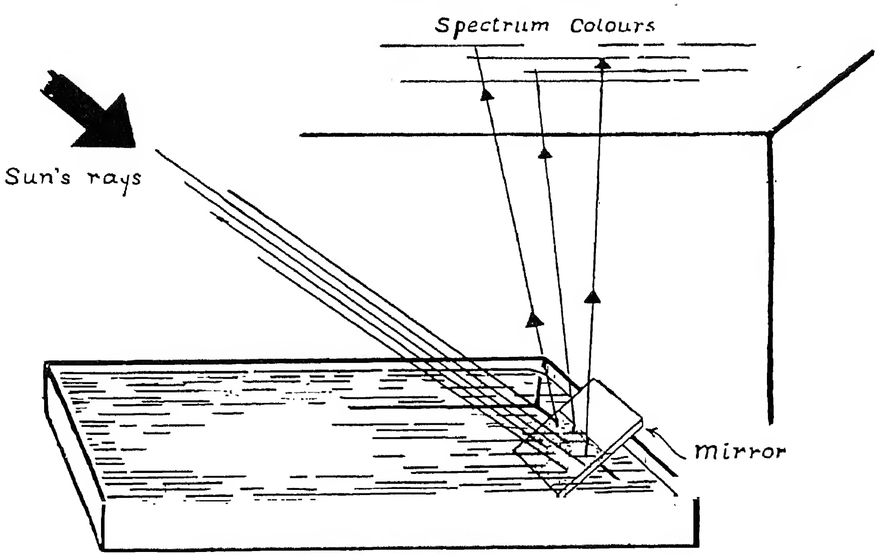


Fig. VI.75. Splitting into the spe

Concept 10-a, b (p. 65): (a) Sunlight passing through a prism is dispersed into several component colours—red, orange, yellow, green, blue, indigo and violet.

(b) The red rays are deviated least and the violet rays most.

Darken a room into which the sun is shining. Make a small hole in the window covering to obtain a thin beam of light. Hold a glass prism in the beam of light and observe the band of colours on the opposite wall or ceiling. What is the colour of the ray that bends least and of that which bends the most?

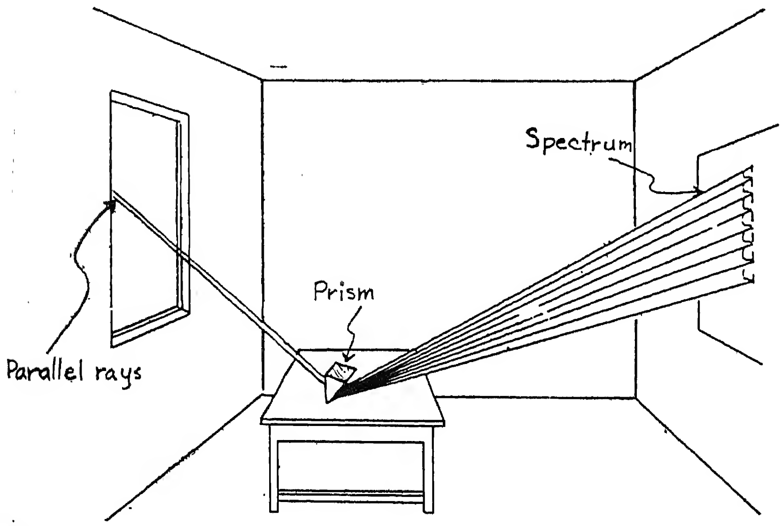


Fig. VI.76. Prism spreads sunlight into spectrum.

Concept 10-c (p. 65): A rainbow is the result of the dispersion of sunlight in the water drops of a cloud or shower. It is seen when the sun is behind the observer and the shower is in front of him.

Raise the problem when a rainbow is seen. Demonstrate the following experiments after discussing the conditions for the formation of a rainbow.

1. Stand a tumbler full of water on a window-ledge, in the room, in bright sunlight. Place a sheet of white paper on the floor. You will observe a rainbow or spectrum band on the sheet of paper.

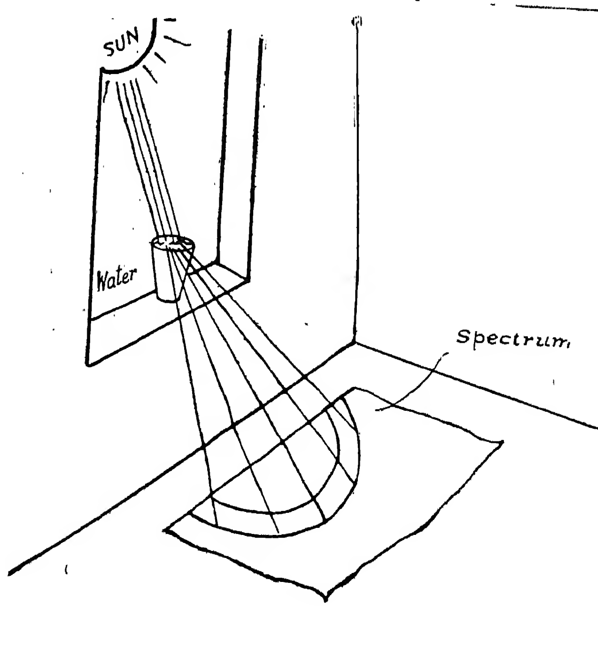


Fig. VI.77. Make a rainbow.

2. Early in the morning or late in the afternoon on a bright sunny day, spray water from a hose against a dark background of trees with your back towards the sun. You will see a lovely rainbow.

Major Concept 11. The colour of an opaque object depends upon which of the colours of white light it reflects to the eye.

Concept 11-a,b (p. 65): (a) If it reflects all the colours it receives, it appears white. If it absorbs all of the light it receives it is black.
(b) The colour of an opaque object also depends upon the colour of the light shining on it.

Obtain a good spectrum on a wall or a sheet of white paper in a darkened room. Place a piece of red cloth in the blue light of the spectrum. What colour does it appear? Place it in the green and yellow colour. How does it appear? Place it in the red light and notice the colour it appears to have. Repeat using blue, green and yellow coloured cloth (you will observe that they appear black except when placed in the same coloured light).

Opaque objects have colours because of the light they reflect; that they absorb other colours of the spectrum. A white opaque object reflects all the colours it receives and a black opaque object absorbs all the light it receives.

Major Concept 12. The colour of a transparent object depends upon which of the colours pass through it.

Concept 12-a, b, c (pp. 65-66): (a) A red glass, for example, transmits red colour and absorbs most of the light of other colours.
(b) Different coloured lights may be combined by placing one colour of glass in front of one projector, another in front of a second projector and then shining both projectors on a single object.
(c) Beams of red, green and blue light may be combined to produce white light.

Make a smoke box out of a packing box about 30 cm. by 60 cm. Fit a pane of glass or plastic into front and top sides. Cover back side of box with loose black cloth. Have a single ray of light enter the box. (refer to Fig. VI.62). Hold a clear sheet of glass or cellophane in the beam of light and note the beam on the screen in the box (It is white.). Next hold a sheet of red glass or cellophane in the white beam. Observe the beam on the screen (It is red.). All the other colours of the white light have been absorbed by the red glass. Experiment with other coloured transparent sheets.

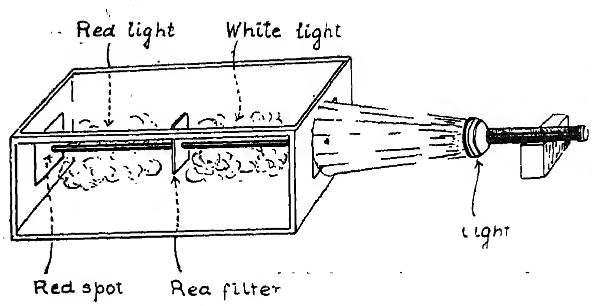


Fig. VI.78. Colour absorption.

Do you conclude that transparent objects have colour due to the colour they transmit and that they absorb other colours?

The colour of an object depends upon the colour of light which falls on it, and upon the colour which it reflects or transmits.

2. To understand what causes the colour of different materials, perform the following experiment :

Cut a flower out of red cover or chart paper and paste it on a sheet of green paper. Illuminate this with red light. What do you observe? (A brilliant red flower with a dark background.) Next illuminate the red flower and the sheet of green paper with green light. What do you observe now? (A dark flower on a bright green background.) Illuminate with blue light the flower and the paper. What do you find? (Both the flower and the background appear dark.)

The colours are mixed in two ways by addition and by subtraction. In the additive method, red, green, and blue light are combined in varying proportions to produce a wide variety of different colours. Red, green, and blue are known as additive primaries. The subtractive primaries are red, blue and yellow. You see the subtractive method to produce many colours while using pigments at the time of painting.

3. You need three separate sources of light and a red, a green and a blue filter to demonstrate the additive method of mixing colours. Use three strong torch lights with a covering of red, of green and of blue cellophane. (For better results use three identical projectors.) Set up the three sources of light side by side and insert one of the three primary filters in the beam of light from each source. Adjust the sources of light until the three coloured beams overlap on a white screen. Observe carefully the overlapping colours. What do you find? (Red and green colours overlap to give rise to cyan (blue-green) and the red and blue result in magneta. Red, green and blue mix to form white colour. The white colour may appear as a shade of grey as the filters you use do not have pure primary colours).

Lenses

Major Concept 13. Lenses are of transparent material with spherical surfaces which refract light.

Concept 13-a, b, c, d (p. 66) :

(a) They may be convex (bulge in the middle). A convex lens may be regarded as two prisms with their bases towards each other.

(b) They may be concave (thinner in the middle). A concave lens may be regarded as two prisms with their apexes towards each other.

(c) A convex lens causes parallel light rays to converge to a point called a 'focus,' a concave lens causes parallel light rays to diverge.

(d) The distance of the focus from the centre of the lens is called its 'focal length.'

There are two types of simple lenses—those thicker in the middle than at the edges, called *convex*, and those thinner in the middle, called *concave*. All lenses are made of some transparent material with spherical surfaces which refract light.

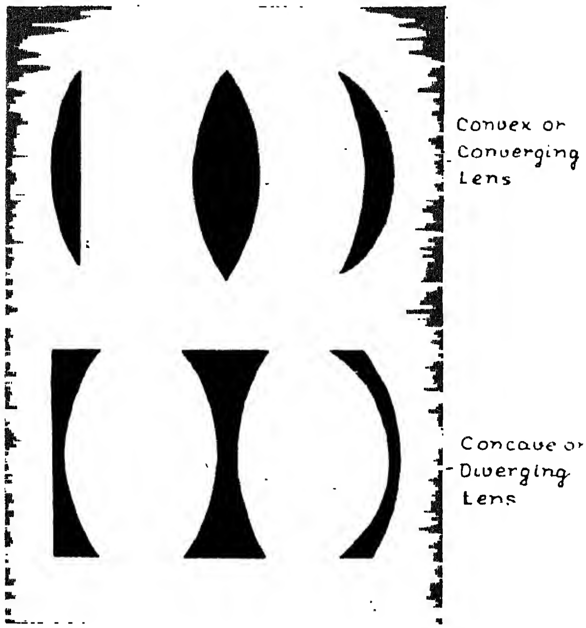


Fig. VI.79. Types of lenses.

A simple double convex lens can be thought of as being made up of two prisms with their bases towards each other. Therefore, light entering the prisms is sent toward their bases, making the rays converge toward one point called the *focus*.

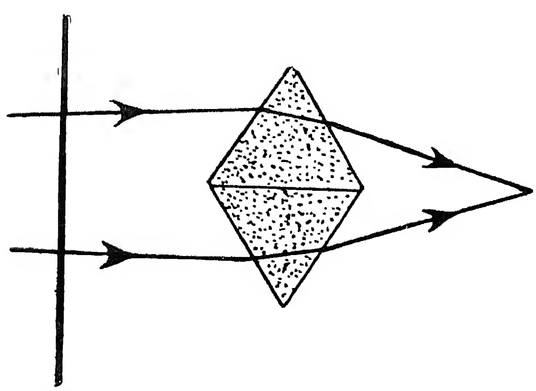


Fig. VI.80. A convex lens is like two prisms base to base.

Concave lenses are shaped like the inner surface of a hollow ball. They are thinner in the middle than at the edges. A double concave lens can be thought of as being made of two prisms with their apexes towards each other. Light that falls on

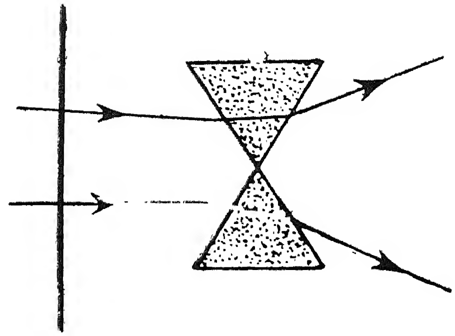


Fig. VI.81. A concave lens is like two prisms with apexes together.

the lenses is sent toward the thicker part of the lens and diverges. Parallel light rays after passing through the concave lens diverge and appear to come from a point on the same side of the lens. This point is called the *focus*.

The distance of the focus from the centre of the lens, concave or convex, is called its *focal length*.

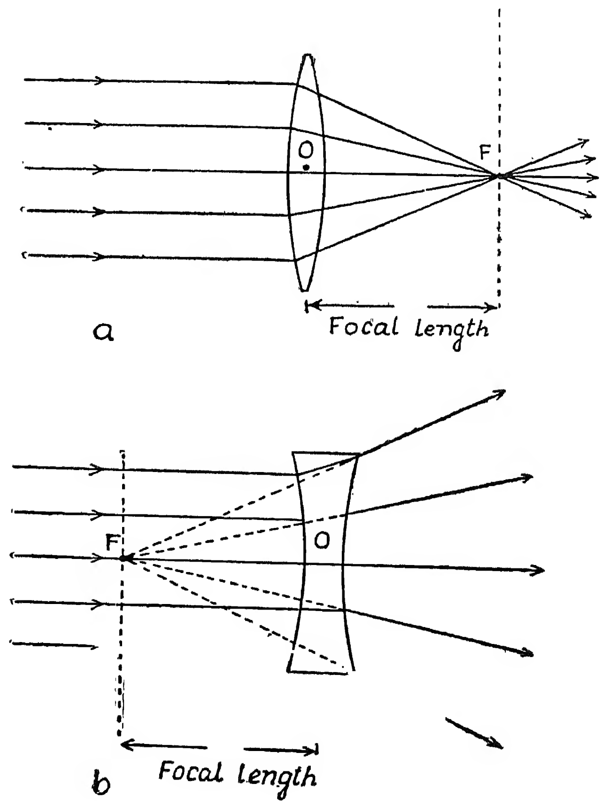


Fig. 82. a,b. Focus and focal length in convex lens (a) concave lens (b).

Insert a convex lens in front of the screen and point the lens towards a distant object out of a window, such as a tree or a building. Move the screen beyond the lens until a clear distant image is seen. Measure the distance from the centre of the lens to the screen. This is the focal length.

Find the focal length of other convex lenses in a similar way.

Major Concept 14. Lenses produce different kinds of images.

Concept 14-a,b,c (p. 66): (a) The image may be real or virtual,
(b) erect or inverted,
(c) enlarged or diminished.

If standard lenses are not available, you can secure lenses from an old pair of spectacles and from used optical instruments, or purchase reading glass lens and hand magnifier for experiments with lenses.

Hold a double convex lens, like the one used for reading glass or hand-magnifier, in front of a window which opens towards far-distant objects. Stand a screen just behind the lens and move the screen slowly away from the lens. What do you observe? Try to obtain a sharp image of the far-distant object on the screen. Is the image formed by the lens large or small? Is the image erect or inverted? Repeat this with other lenses, thicker and thinner than the one used already.

Major Concept 15. For a convex lens, the object and its images have certain relationships.

Concept 15-a,b,c (p. 66): (a) When the object is located between one and two focal distances from the lens, the image is enlarged, inverted and real.
(b) When the object is located more than two focal distances from the lens, the image is formed between one and two focal distances from the lens. It is diminished, inverted and real.
(c) When the object is located less than one focal distance from the lens, the image is erect, enlarged but virtual.

A convex lens forms real or virtual images depending upon the distance of the object from the lens. If an object is at a large distance from a convex lens, the image is formed at the focus of the lens. This is the smallest and nearest image that the lens can form. As the object is made to approach the lens, the image recedes from the lens and becomes larger. When the object is at a point twice the focal length from the lens, the image recedes to an equal distance from the lens and is as large as the object. If the object is brought still further towards the focus, the image diminishes in size as it recedes to a great distance. It reaches infinity when the

object is at the focus. When the object is moved to a distance less than the focal length from the lens, the image becomes virtual and appears on the same side of the lens.

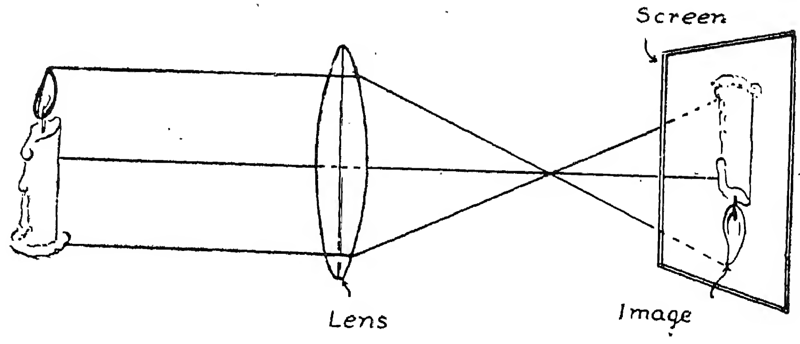


Fig. VI.83. How a convex lens produces an image of object 2 focal lengths away.

Major Concept 16. A lens or a combination of lenses have many applications in life.

Concept 16-a, b, c (p. 67):
(a) A convex lens is used as a burning glass.
(b) A convex lens is used as a magnifying glass.
(c) A convex lens is used in a photographic camera.

1. Visit a science laboratory to see as many optical instruments as possible. Find out about their lenses.

2. Obtain a camera. Study the role of the lens in the camera.

3. List the important uses of lenses, specially as their applications in life such as the eye-glasses (spectacles), and torch light glasses.

Concept 16-d (p. 67): A compound microscope is a combination of convex lenses located in the objective and eye piece. An object which is between F and 2F of the object glass produces an enlarged image which, being between the eye piece and its focus, produces an enlarged virtual image.

See Fig. III-6. If there is a microscope in your school, arrange to borrow it so that the class can study how it works.

Concept 16-e (p. 67): A telescope is a combination of two convex lenses—the object glass and the eye piece. A distant object, which is much beyond 2F of the object glass, produces a diminished image between the eye piece and its focus. The eye piece then produces an enlarged virtual image.

See activities 2 and 3 of Unit XI, Class VIII, Concept 1b. Study the diagrams of reflecting and refracting telescopes.

Major Concept 17. The eye has a convex lens. In fact, the eye and the camera are alike in many ways.

Concept 17-a, b (p. 67): (a) The lens forms an image on the retina at the back of the eye.
(b) The parts of the eye and the camera correspond as follows:

eye	camera
eyelids	shutter
iris	iris
lens	lens
retina	film

1. Hold a small round transparent glass container like a fish globe between a source of light and a white screen. You can improvise a round transparent glass container from a used large round electric bulb. Move the screen towards the round glass container and away from it. Can you obtain an image of the source of light on the screen? (No.) Fill the glass jar with water. What do you observe now? (An image of the source of light at a proper distance from the jar.) Is the image of the source of light you obtain on the screen, erect or inverted ? Conclude that images can be formed by a lens made of any transparent substance such as water or gelatine.

2. Make a gelatine lens by allowing a solution of clear gelatine to harden in a watch glass or a dish of similar shape. Use the lens to obtain images.

3. Obtain the eye of a goat or another animal from a butcher. Cut this open carefully with a very sharp pen-knife. Inside you will find a rather soft piece of matter which looks like glass. Observe it carefully. Does it resemble a double convex lens? Drop it into a glass jar containing water. Observe its shape in the water. Press it gently between your fingers in the water to vary its thickness in the centre. You will notice that the eye of an animal is like a converging lens which can be made to have different focal lengths. In actual practice the eye-lens forms an image on the retina in the back of the eye.

4. Study the working of the human eye from the charts and models available in the school or with a doctor.

5. Study the working of a camera. Compare the camera with the model of the human eye. Try to find the parts of the eye which correspond to that of the camera.

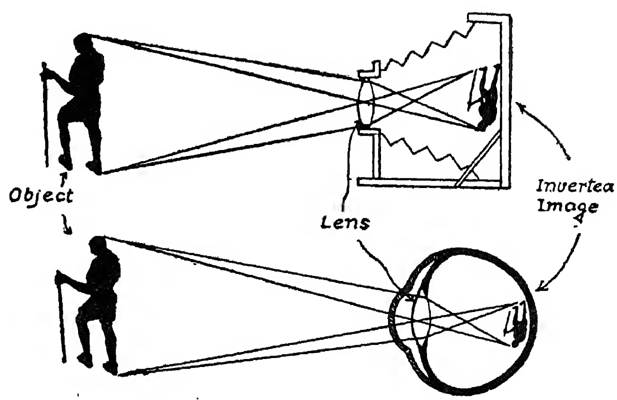


Fig. VI. 84a. The eye and the camera.

Major Concept 18. Either one or both eyes of a person may be imperfect in structure and need correcting.

Concept 18-a,b,c,d (pp. 67-68) : (a) The retina may be too near or too far away from the lens causing blurred images.

(i) Short-sight is rectified by using a concave lens.
(ii) Long-sight is rectified by using a convex lens.

(b) Other eye defects may be due to an incorrectly shaped eye ball or to weak muscles. Properly fitted glasses may prevent eye strain.

(c) Healthy corneas may be transplanted to overcome certain kinds of blindness.

(d) Trachoma can be prevented by proper care of the eyes.

Normally an eye forms on the retina clear images of objects at any distance between infinity and 25 cm. In a defective eye, the eye lens may be too thick for the depth of the eye ball, so that the eye forms images in front of the retina for objects at normal distances. Distant objects are blurred. This defect is known as short-sight and is rectified (not cured) by using a concave lens.

An eyeball too short for the convexity of the lens results in another defect known as long-sight. In this case the image of the objects at normal distance is formed by the eye behind the retina. Near objects appear blurred. Long-sight is rectified by using a convex lens which aids the eye lens to converge the light properly upon the retina.

1. Can you tell the eye defect of a friend of yours who wears glasses? Compare the lens of the glasses used by a person having short-sight with those of a person having long-sight. What do you find?

2. Visit an opthalmologist to find out more about the defects of human eye, and the ways adopted to overcome the defects.

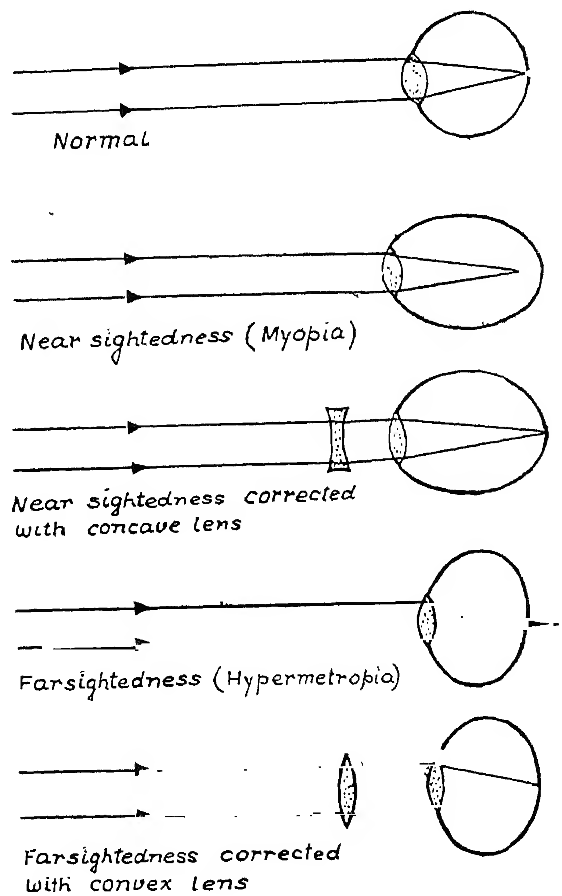


Fig. VI. 84b. How lenses correct eye defects.

WORK AND ENERGY (ENGINES)

Major Concept 1. New machines and new forms of energy improve our living conditions.

Concept 1-a (p. 68): Wind and flowing water were the first forms of energy used to do work without the use of muscles.

Think of various ways that wind is used to do work and explain how the wind does work in each case. Remember that when work is done, a force acts through a distance, and that energy is used. In the case of wind, it is the kinetic energy of the wind that moves things. The energy of movement of the wind makes something else move. As the energy from the wind is absorbed by something else, then the motion of the wind is slowed down, or the direction of the wind is changed.

In winnowing grain, wind is used to blow the chaff away from the grain. How does the wind separate the grain from the chaff? Doesn't the wind push against both the grain and the chaff? Mix some grains of rice with tiny bits of paper and see if you can separate them by winnowing.

In flying a kite, the moving wind does work in pushing the kite up into the air. Make a kite, fly it, and explain how the wind takes the kite up in the air. How does the tail hold the kite steady? What do you do with the string?

Sail boats are pushed by the wind. If you live near a lake you may be able to get someone to take you for a sailboat ride. You may find out just how the sail is used to push the boat, and how the keel and the rudder are used in manouvering the boat. Must the boat always sail with the wind, or can it sail across the wind and even into the wind?

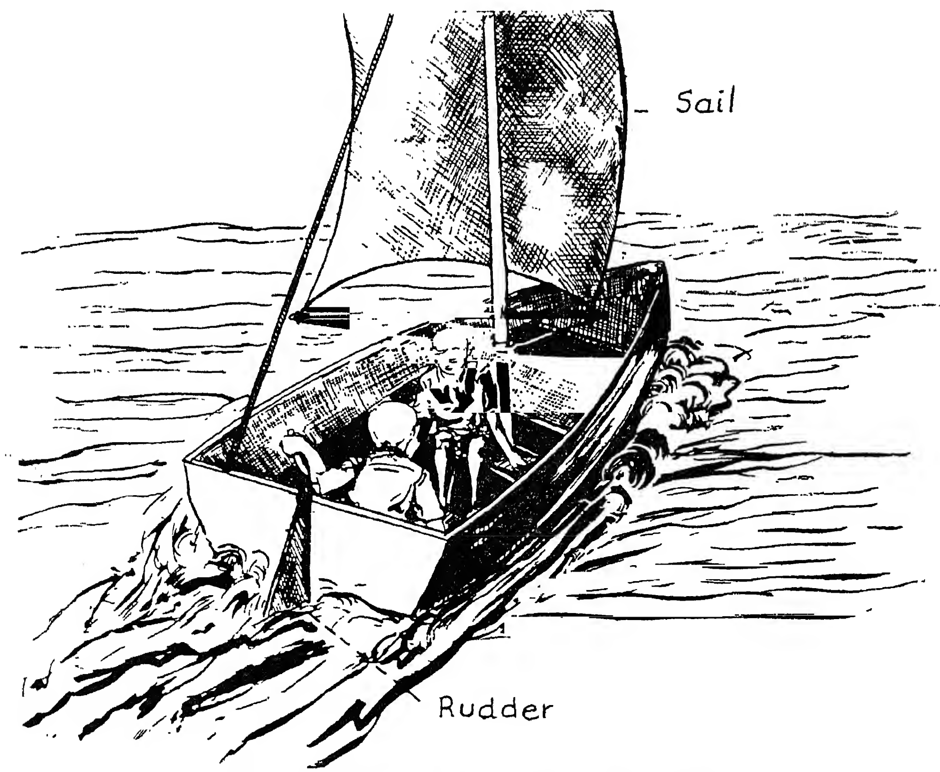


Fig. VI.85. How are sail boats pushed by wind ?

Make a small toy sail boat and find just how a sail boat sails in this way. Perhaps the simplest sail to use is a triangular shaped sail tied between two poles, with the poles suspended on a mast, as in the figure. You can use a boat-shaped board for your boat. You will need a keel and a rudder.

Concept 1-b (p. 68): An important early discovery was the advantage of the wheel in using the energy of wind and flowing water.

1. Wind mills are used on some farms and in stations far from other sources of power, to pump water, to generate electricity and even to grind grain. To show how the wind can be made to turn a wheel, make a small pin wheel and hold it in the wind. You need a small stick, a pin, and a piece of paper about 13 centimeters square. With scissors, cut out the square of paper, crease it gently from opposite corners to locate the centre of the square. Then cut from the corner half way to the centre along the crease. Put a pin through each alternate tip, through the centre and into the end of a stick. Your pin wheel looks like this.

2. Most water wheels and all turbines use the kinetic energy of water to turn them. However, there is one type of wheel, known as the *overshot water wheel* which uses the potential energy of water to turn it. In this case the water is caught in buckets on one side of the wheel. The weight of this water on one side of the wheel makes the wheel turn. Such wheels are not used much now-a-days, but they are effective as a source of power where a small stream falls from a height of several meters. (Refer to Fig. VI.2.)

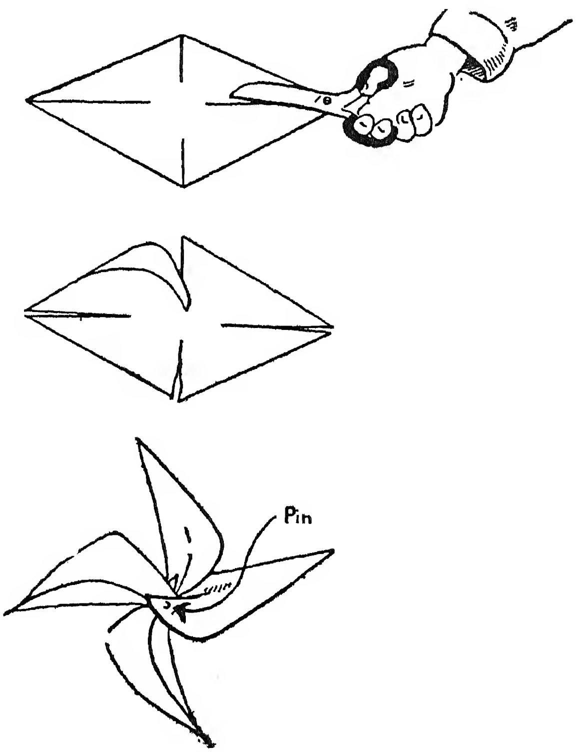


Fig. VI.86. A pin wheel.

Concept 1-c (p. 68): Machines were invented which could use the energy of flowing water and moving air to do many tiring jobs quickly and easily.

You might construct a small model of an overshot water wheel to demonstrate how the weight of the water turns the wheel. (Refer to Fig. VI.4.)

The simplest of the *undershot* water wheels is a paddlewheel so arranged that water rushing in a sluice-way beneath the wheel makes it turn. What makes the water rush out at the bottom of the sluice gate? Will the height of the water behind the sluice gate affect the rate at which the water rushes through the gate? Where is the potential energy of the water (which is stored at the back of the gate) changed to kinetic energy? An advantage of the undershot water wheel is that it can be used in flat countries where the water does not flow down from a great height.

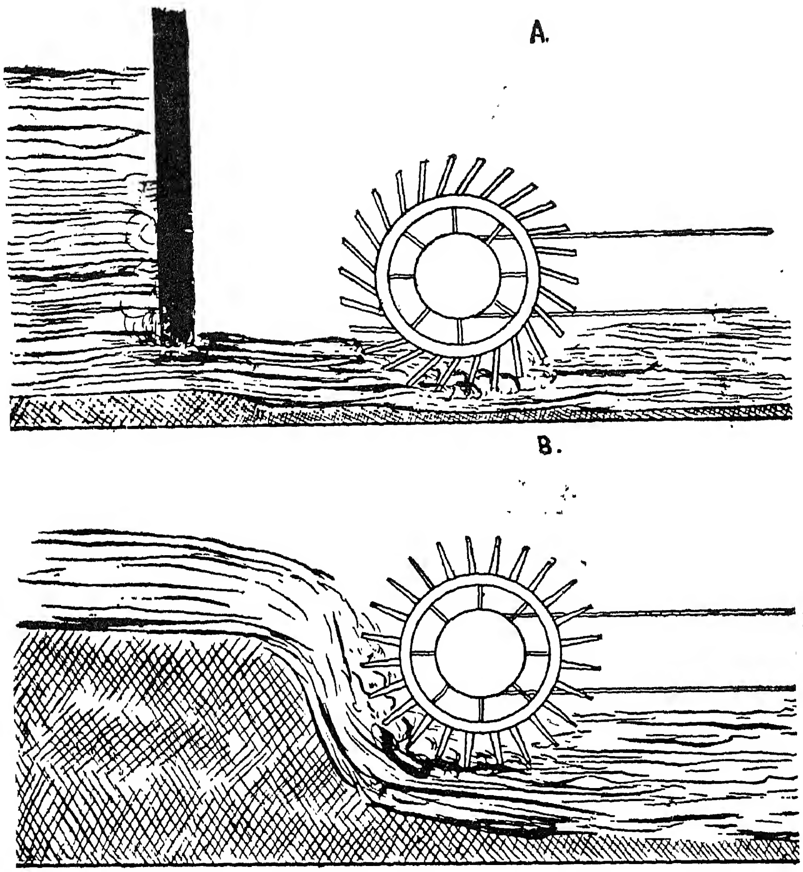


**Fig. VI. 87 a. Undershot water wheel and sluice gate.
b. Breast wheel.**

The *breast wheel* is similar to the simple undershot wheel, but is arranged as shown in the figure above so that the moving water is in contact with many of the paddle wheels.

The *Pelton wheel* is the most efficient of the undershot wheels. In this case water is led down from where it is stored through a penstock. It is squirted through a nozzle against the cup shaped paddles on the wheel. With this arrangement nearly all the kinetic energy of the jet is absorbed by the turning wheel.

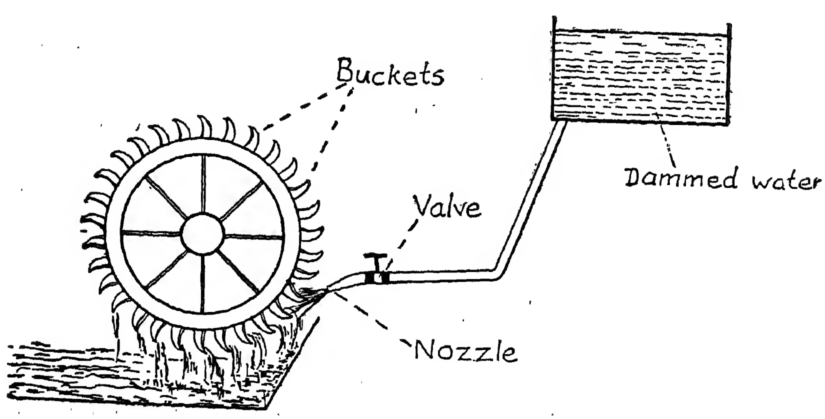


Fig. VI. 88. The Pelton wheel.

To see how the potential energy of water is converted into kinetic energy in the nozzle of a penstock or hose, hold your thumb over the end of a garden hose and see how much farther the water squirts. Make and demonstrate the action of a small *Pelton wheel.*

Concept 1-d (p. 68): Now turbines turned by the energy of flowing water drive electric generators, which produce electric power.

In a water turbine, the water flows from a penstock into one side where it strikes curved blades on a horizontal wheel. The spent water falls from below the centre of the wheel.

If there is a hydro-electric power plant in your vicinity, arrange a trip to see how the turbines are used to turn huge dynamos which generate electricity.

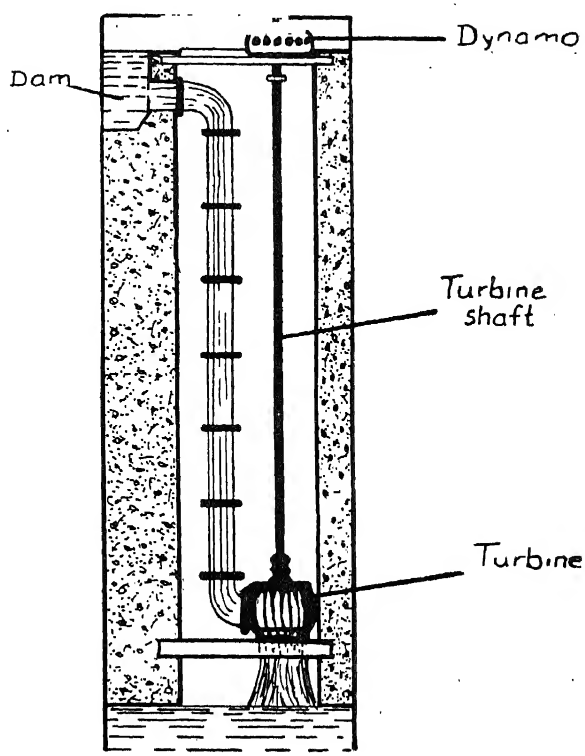


Fig. VI. 89. Water turbine.

Major Concept 2. Modern steam engines are of two types—the wheel type and the piston type.

Concept 2-a, b (p. 68): (a) The wheel type of steam engine is called a steam turbine.
(b) When blades on a wheel are pushed by steam, the wheel spins.

To make a model *steam turbine*, first cut radial slots from a circular piece of tin sheet and twist the blades to remain perpendicular to the plane of the tin sheet. Punch a hole in the centre and pass a knitting needle as axle. Bend another piece of tin into a U-piece with two holes and solder this on the lid of a kilo-sized tin. Make a fine hole near the base of the U-piece. Insert the axle through the holes for support as shown in Fig. VI.90.

Fill the can with about a fourth part with water and close the lid tightly.

Heat the water to boiling till steam escapes through the hole and moves the blades.

A steam turbine has blades which are pushed by the steam striking them. It is much like a water turbine, only its rotor turns vertically rather than horizontally. Instead of having just one row of sloping blades on the rotor, it has many rows fastened along the same shaft. In front of each row of rotor blades is a row of stationary guide blades which redirect the steam against the rotor blades to make them all push in one direction. As the steam moves through each successive set of blades, it expands so that each successive wheel is larger. In large turbines steam moves from small wheels on the middle of the shaft towards the larger rotors at the ends.

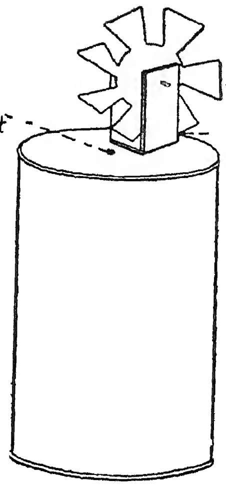


Fig. VI. 90. Model steam turbine.

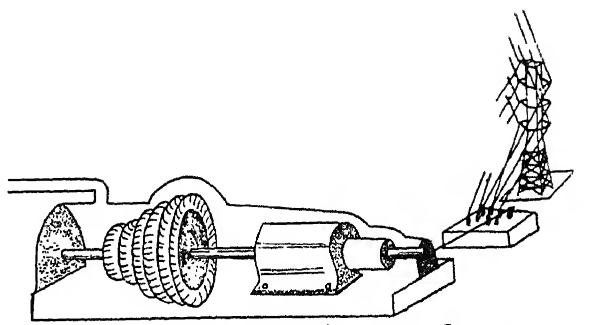


Fig. VI. 91. Steam turbine.

Concept 2-c (p. 68):	In the piston type of steam engine the steam is let into a large tube called a cylinder. The piston which fits tightly inside the cylinder moves in and out when pushed by steam. The piston moves a rod that turns a wheel.

To see how a *piston* type steam engine works, study Fig. VI.7, and then visit a railway station or a power station to see this type of engine in operation. Note how the steam is controlled by the slide valve, and how this valve lets the steam into one end of the cylinder as the steam at the other end of the cylinder is let out.

If a toy steam engine is available, operate it to show how the steam in the cylinder makes the wheels of the engine turn.

Concept 2-d (p. 68):	The steam for the steam engine is produced in a boiler heated by coal or oil. In locomotives the hot gases from the fire pass through tubes inside the boiler. In most power plants the hot gases pass around water-filled tubes.

Boilers are designed to transfer heat rapidly from the fire in the fire box to the water in the boiler. Many tubes are used to increase the surface between the hot gases and the water. In locomotive boilers, for example, the tubes carry the hot gases forward from the fire box to

the chimney. So this type of boiler is called a *fire tube boiler*.

In most power plant boilers, however, the water and steam circulate in the tubes and the hot gases from the burning fuel are made to pass around the water-carrying tubes before going up the chimney. These boilers are called 'water tube boilers.' If possible, arrange a trip to see either or both types of boilers.

Major Concept 3. In a petrol (gasoline) engine, power is obtained from the burning of petrol in a cylinder.

Concept 3-a (p. 69): In a petrol engine a spark plug produces an electric spark that sets fire to a mixture of fuel and air which burns in the cylinder.

Petrol engines are called *internal combustion* engines, for the fuel burns right inside the cylinder. The hot burning gases push the piston directly. How do these differ from the steam engines? Engines in which the fuel is burnt in a boiler, are classed as *external combustion engines*.

To ignite the fuel in a petrol engine, there is a spark plug placed in the end of the cylinder. At just the right time, a spark occurs, igniting the fuel. (See Electricity—concept 2-e to see how the spark is produced.) The vapourized fuel burns quickly in the cylinder; the exploding gases push the piston and so turn the engine.

To demonstrate how exploding gases push, explode some petrol in a can making the lid blow off the can. Procure a tin of about ½ to 1 litre capacity and provided with a friction cover. With a nail make a ½ cm. hole near the top. Place a lighted candle just below the hole. Introduce from 2 to 4 drops of petrol into the can. Put on the lid and heat to vapourize the petrol. If you have everything adjusted properly, the petrol vapour should mix with the air in the can. The lighted candle should light the explosive mixture and the top should blow from the can. This demonstration should be carried out only under adult supervision. Be sure all observers are about 2 metres away from the exploding can.

It is easier to demonstrate how exploding gas pushes, using the gas from a gas jet. Select a can with a friction top of about a litre capacity. Make a small hole in the top with a nail. Make two larger holes near the bottom, one on each side, the size of a rubber tube used in a science laboratory. Fill the can with gas by putting a rubber tube in one of the holes and turning on the gas for about half a minute. Then remove the tube and light the gas at the hole in the lid. It should burn much like a candle flame at first. Air moves into the can through the holes at the bottom. The air pushes the gas out of the top of the can. As the air mixes with the gas, the flame becomes blue and almost invisible. When enough air has mixed with the gas the flame should set off an explosion inside the can and blow off the lid.

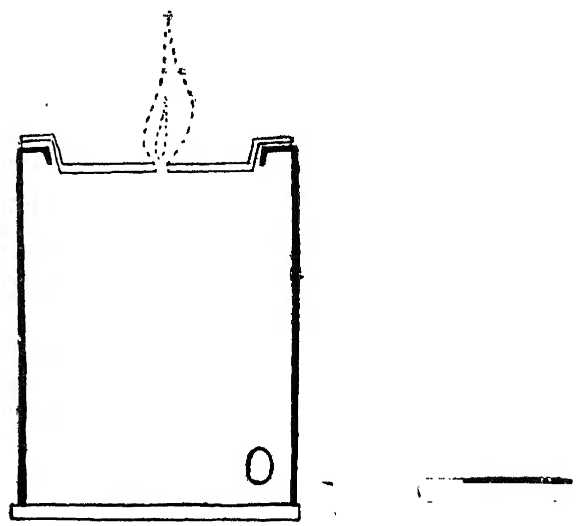


Fig. VI.92. How exploding gases push.

To burn explosively there must be the right mixture of petrol vapour and air. This mixture is made in the carburetor. As air rushes in through the narrow neck or *venturi* of the

carburetor, petrol flows through the nozzle jet mixing with the air as a fine spray. (Some of you know way how an atomizer works.) These tiny droplets of petrol evaporate as they move towards the engine and so enter the cylinder as an explosive mixture. The figure below shows a simple carburetor.

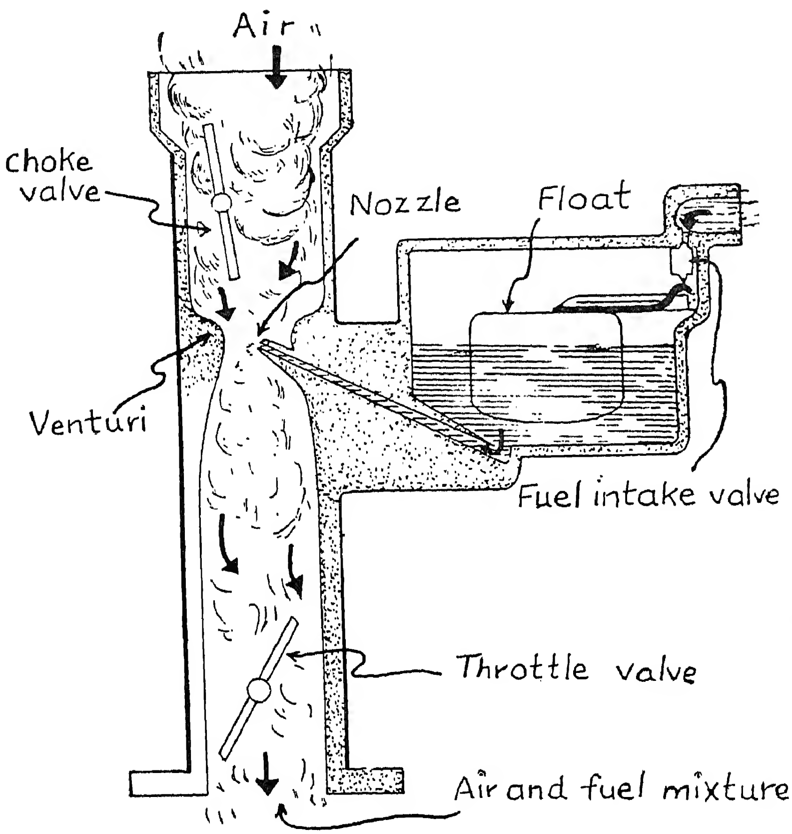


Fig. VI.93. Operation of carburetor.

Concept 3-b, c, e (p. 69): (b) Each explosion pushes the piston in the cylinder. The motion of the engine brings the piston back again.
(c) The piston pushes a rod that turns a crank shaft which in turn, turns the wheel.
(·) In each cylinder there are four strokes for each explosion namely, intake, compression, power, exhaust.

* Concept 3-d is found on page 215.

Most petrol engines are four stroke engines—that is, the piston moves up and down four times for each explosion. The complete cycle consists of (1) an *intake* stroke when the explosive mixture is drawn into the cylinder, (2) a *compression* stroke, when the explosive mixture is compressed, (3) a *power* stroke, when the fuel explodes and pushes the piston, and (4) an *exhaust* stroke when the waste gases are expelled from the cylinder. See Fig. VI. 94 showing the four strokes of each cycle. This kind of an engine is called a *four cycle engine.*

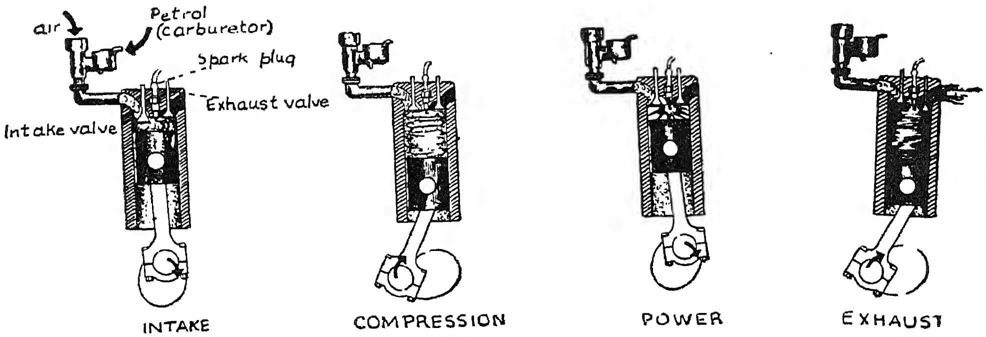


Fig. VI.94. Four stroke internal combustion engine.

If possible bring a small engine into the classroom—take it apart, see how it works, then put it together and make it run again. Often one student knows a great deal about automobile engines. Let him demonstrate to the class.

Some small petrol engines are two cycle engines. These two cycle engines complete the intake, compression, power and exhaust in two strokes of the piston. Intake and compression take place on the up-stroke of the piston, power and exhaust on the down-stroke of the piston. To accomplish this the fuel mixture is drawn into the crank case and compressed. At just the right time this compressed gas is forced into the cylinder from the crank case. Some scooter engines and others are of this type. Try to examine this type of engine to see how it works.

Concept 3-d (p. 69): In automobile engines there are several cylinders coupled together to work as one engine.

Each automobile engine is really four, six or eight four-cycle engines combined into one single engine. Each cylinder may be considered an engine. In each cylinder all four strokes occur in each two revolutions of the crank shaft. So in a four cylinder engine there is a power stroke in one of the cylinders for each half revolution of the crank shaft.

Major Concept 4. A diesel engine works something like a petrol (gasoline) engine, but it uses a fuel oil and has no spark plug.

Concept 4-a, b (p. 69): (a) Air is drawn into the cylinder. This air is compressed. As it is compressed, it is heated.
(b) A jet of atomized fuel oil is injected into the engine at just the right time.

Unlike the ordinary petrol engine, in a diesel engine the explosive mixture of petrol and air is not ignited by a spark plug. Instead it is ignited by the heat generated as air is compressed in the cylinder. The petrol cannot be mixed with the air before it is drawn into the cylinder—for the heat generated by compressing the mixture would make it explode too soon. So a fine jet of petrol is pumped into the cylinder at just the right time—at the beginning of the power stroke. It burns explosively in the hot compressed air. As the compression ratio is higher in diesel

engines than in ordinary petrol engines, they are more efficient, that is, they do more work for each litre of fuel used.

Find if some diesel engine is operating near your school and if so, plan a visit to see how it works. Many trucks and locomotives are run by diesel engines.

To see how compression heats a gas, push down a bicycle pump handle while keeping air from escaping. Note how hot the pump cylinder becomes as you compress the air in it.

Major Concept 5. In a gas turbine, heat energy is used to turn a wheel with many blades on it.

Concept 5-a, b (p. 69): (a) Until recently all aeroplanes were driven by piston engines. Now most aeroplanes are driven by turbo jets or by jets.
(b) The blades are pushed by expanded hot gases.

A *turbo* jet engine operates much like a steam turbine, except that instead of steam, hot burning gases turn the turbine. This type of engine operates with less vibration than a piston engine, for there is no back and forth motion as in the case of a piston engine. Also these engines generate more power per kilogram of weight than do piston engines. Consequently these engines are preferred on propeller driven 'planes.

Visit an airport hangar to see a turbo jet engine, if possible. Also look for jet engines without propellers.

Major Concept 6. A jet engine has two main parts—an air pump and a gas turbine.

Concept 6-a, b, c (p. 69): (a) The air pump draws in air and compresses it.
(b) The gas turbine uses some of the energy of exhaust gases to drive the air pump.
(c) The rapid expulsion of hot exhaust gases gives thrust.

A jet engine is like a turbo jet except that only a small part of the energy of the expanding gases is used to turn the turbine. In this case, the aeroplane is pushed forward by the backward movement, the expulsion of the exhaust gases.

To show how the backward ejection of gases gives forward thrust, visit an airport and observe the backward wind from a jet plane as it moves towards the runway. See how all the grasses and plants behind the jet are blown

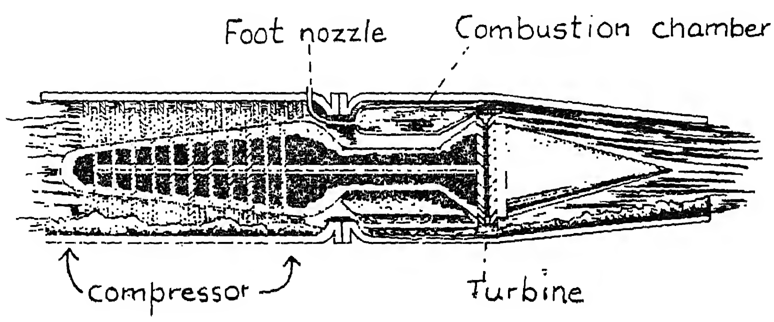


Fig. VI.95. How a jet engine works.

violently by the jet of gases issuing from the plane.

Or, suspend a long inflated balloon on a soda straw on a tightly stretched wire. Let out the air from the balloon through a tiny tube placed in the mouth of the balloon. As the air escapes from the tube, the balloon should slip along the wire at high speed.

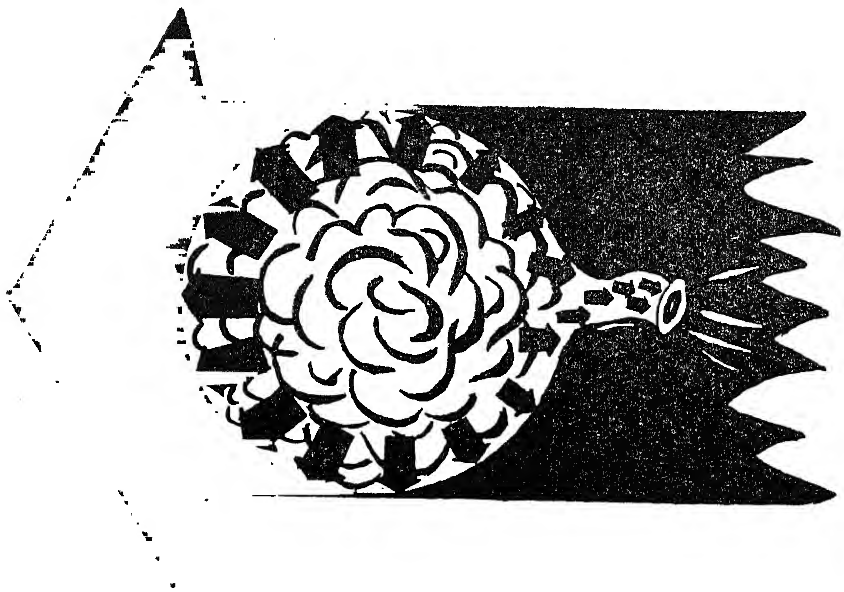


Fig. VI.96 a. Action-reaction.

Major Concept 7. A jet engine gets its name from the stream (or jet) of compressed air and burnt gas which rushes out behind the engine.

Concept 7-a, b (p. 69) : (a) Jet engines are lighter for their power than are conventional engines.
(b) In a conventional plane, the tip of the propellers exceed the speed of sound long before the plane reaches that velocity. Thus jet planes can go faster for they are not held back by the drag of the propellers.

To demonstrate that when something is made to move backwards, the thing that made it move backwards is pushed forward, suspend a bottle of water on a string in such a way that as the water flows out, it makes the bottle turn. Bend glass tubes in such a way that they will throw water backwards as the bottle turns. Fix these tubes in a rubber stopper, and also a third tube to admit air to the bottom of the bottle. Then fill the bottle with water and suspend it in an inverted position with a string. If the string is properly attached, the bottle should spin. See Fig. VI.96b.

To compare the relative advantage of different kinds of engines for propelling aeroplanes, find some

good book, magazine, or some person who is informed about these engines and assemble comparative facts regarding each. Report your findings to the class.

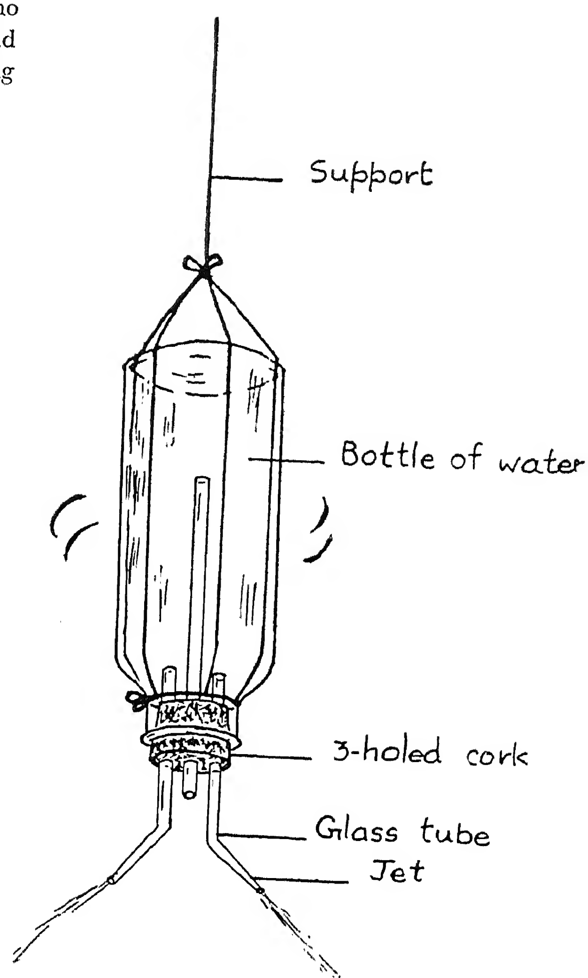


Fig. VI.96 b. Jets of water in one direction can turn in opposite direction.

Major Concept 8. A rocket engine carries its own oxygen as well as its fuel.

Concept 8-a,b (p. 70): (a) To fly to the moon a rocket engine would be needed.
(b) When the fuel and oxygen meet and burn in the combustion chamber of a rocket engine, they produce great quantities of heat and compressed gases, which push the rocket plane forward.

To travel beyond the earth's atmosphere both the fuel and the oxidizing agent must be supplied, for there is no oxygen in space to combine with the fuel. Some *rockets* use solid propellants. These consist of a fuel and some oxidizing agent.

You can demonstrate the rapid burning of a mixture of a fuel and an oxidizing agent. If you do this, use only a small amount of material. Use about half a teaspoonful of finely pulverized sugar as a fuel, thoroughly mixed with half a teaspoonful of finely powdered potassium chlorate, an oxidizing agent. Thoroughly mix the fuel and the oxidizing agent. Place the mixture on a pan and burn it. Watch what happens.

Major Concept 9. The 25,000 miles per hour speed needed to escape from the earth's gravity is attained by using a three-stage rocket.

Concept 9-a (p. 70): By using several stages, useless mass is discarded and the small 'pay load' can be made to move faster.

Perhaps you have noticed how much quicker a motor cycle or a scooter starts than a heavily loaded truck or bus when a traffic light turns green. The more mass an object possesses, the more energy it takes to set it in motion.

You can demonstrate this relationship by devising some way to give equal thrusts to balls of different mass. Why not arrange a spring at one end of a table or at one end of a room in such a way that you can repeatedly bend it the same amount, and suddenly release it. A hacksaw blade can be used as a spring. To give equal impulses to different balls, tie the spring in a bent position with thread and then cut the thread with scissors or burn it with a match. You can compare how far it will make a light marble and a heavy marble roll. If the light marble rolls further than the heavy marble it does so because it is going faster. If this happens, then you have demonstrated the advantages of using *multiple stage rocket engines*.

Your experiment might look like the diagram of this one on a table top. Measure how far marbles of different weights roll. (Fig. VI. 97.)

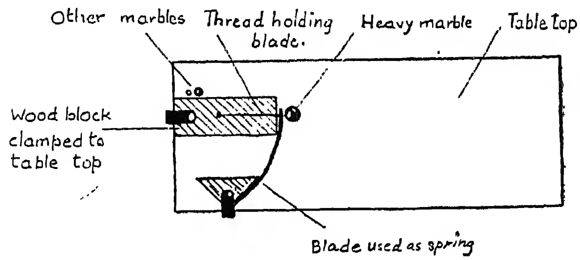


Fig. VI.97. The more mass an object possesses the more energy it takes to set in motion.

Concept 9-b,c (p. 70): (b) To orbit the earth an object has to get high enough and go fast enough at this height, so that even though it is falling towards the earth all the time—it travels so fast it keeps going around the earth.
(c) Rockets may attain a speed of 25,000 m.p.h.

One can visualize the forces at work when an object goes into orbit by having someone drop a marble from one end of a table. At exactly the same time another marble rolls off the end of the table. Both marbles will strike the floor at the same time. Yet the rolling marble may move entirely across the table before it strikes the floor. The force of gravity acts on both marbles at the same rate regardless of the motion of the rolling ball in a direction parallel to the floor. The faster the marble is rolled, the farther it will travel before reaching the floor.

Similarly a rifle bullet fired horizontally will travel several metres before striking the earth. The momentum of the bullet keeps it going in a straight line, while the pull of gravity makes it move towards the earth. If the rifle were fired horizontally from a mountain top five miles high, it would travel a long distance before striking the earth. Momentum of the object and the pull of earth's gravity control the motion of all satellites, either natural or man-made.

If a rocket could be fired straight up for about 400 miles and then horizontally at about 25,000

miles per hour, it would go into orbit, for even though it would be falling towards the earth all the time, its horizontal velocity would keep it circling the earth—one might say that the earth curves away from it, if it is going this fast. As it circles the earth, the direction of gravitational pull changes.

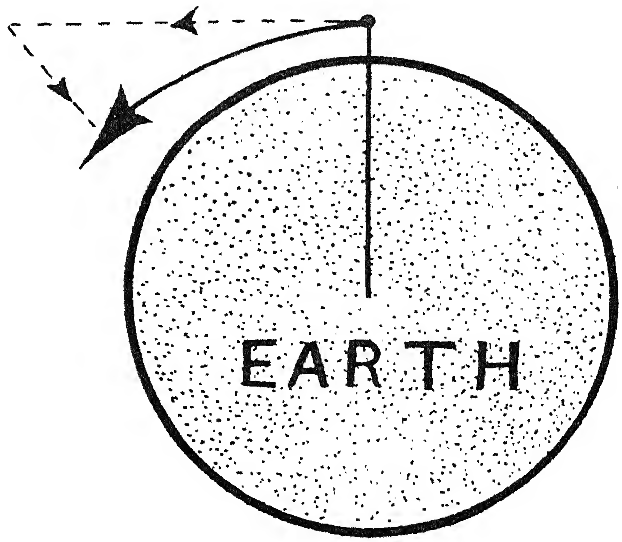


Fig. VI.98. Velocity and gravity control the motion of all satellites.

Work and Energy (Atomic Energy)

Major Concept 10. The atomic energy in radium is given off in flashes for thousands of years.

Major Concept 11. Scientists have found a method of making a vast number of atoms give off their energy, at once yielding an enormous amount of light and heat.

Major Concept 12. Scientists can increase or decrease the speed of this chain reaction.

Major Concept 13. Scientists have discovered many uses of atomic energy.

As a background for concepts 10-13, certain basic information is presented. An element is a basic substance that cannot be broken down chemically into anything simple. Examples are hydrogen, carbon, nitrogen, oxygen, aluminium sulphur, iron, silver, gold, mercury.

An atom is the smallest particle of any element. Each atom consists mainly of electrons, protons, and neutrons. (See Energy, Class VII, Electricity, concepts 1 to 3).

An electron is a negatively charged particle—the basic unit of electricity. This particle is relatively light.

A proton is a positively charged particle—the basic unit of positive electricity. This particle is relatively heavy, weighing 1840 times as much as an electron. It is present in the nucleus of atoms.

A neutron is a neutral particle having the same mass as a proton. It is found in the nucleus. It may be thought of as a combination of a proton and an electron when building a simple image of the atom.

The nucleus is the core of an atom which contains almost all of the mass of the atom and which consists mainly of protons and neutrons. All elements are believed to consist mainly of

protons, neutrons and electrons. Most of them have several *isotopes*.

An isotope is an atom of an element having a particular mass that may be different from other atoms of the same element., but which has identical chemical properties with other isotopes of the same element.

The number of electrons flying around the nucleus of an atom is normally the same as the number of protons in the nucleus of that atom. However, in the presence of electrical charges, some atoms may lose electrons and become positively charged, while other atoms may gain electrons and become negatively charged.

The atoms of the different elements can be arranged in a *periodic table* in the order of their increasing atomic weight, and given atomic numbers which rank them from the lightest to the heaviest atoms. When this is done, it is found that the chemical properties of the heavier atoms repeat those of the lighter atoms in a periodic way. The chemical properties depend upon the number of electrons around the nucleus. The number of electrons around the nucleus of each atom depends in turn upon the number of protons in the nucleus which number is the atomic number of the element. The mass of each atom may be considered as the sum of the masses of all the neutrons and the protons, and since the mass of each proton is essentially the same as the mass of each neutrons, we may say that the mass of each atom corresponds to the total number of protons and neutrons in the nucleus of each atom.

Actually, were it not for the fact that the number of neutrons varies in different isotopes of each atom, the masses of the atoms of different elements would be represented by small whole numbers, with Hydrogen as 1, Helium as 4, Lithium as 7, Carbon as 12, Nitrogen as 14, Oxygen as 16 and so on. But actually the atomic weights cannot be represented this simply, for the atoms of most of the elements occur as different isotopes. This can be readily seen by glancing at the portion of the periodic table shown below. The number below the symbol for an element is the atomic number. This number is the rank number of the atoms when they are arranged in order from smallest mass to largest mass. The number above the symbols are the relative atomic weights of the atoms. These atomic weights are based on the atomic mass of Carbon 12 as 12, according to international agreement in 1961. Consequently, these atomic weights differ slightly from those based upon oxygen as 16.

TABLE VI.1. PORTION OF THE PERIODIC TABLE

PERIOD	I	II	III	IV	V	VI	VII	VIII
1.	1.008 H I							4.003 He 2
2.	6.939 Li 3	9.012 Be 4	10.811 B 5	12.011 C 6	14.007 N 7	15.999 O 8	18.998 F 9	20.183 Ne 10
3.	22.990 Na 11	24.312 Mg 12	26.981 Al 13	28.086 Si 14	30.974 P 15	32.064 S 16	35.453 Cl 17	39.948 As 18

The names, symbols and atomic number and approximate atomic weights for the atoms of certain elements are given here for reference:

TABLE VI. 2. ELEMENTS AND THEIR ATOMIC WEIGHTS

Elements	Symbols	Atomic Number	Approximate atomic weight	Elements	Symbols	Atomic Number	Approximate atomic weight
Hydrogen	H	1	1	Lead	Pb	82	208
Helium	He	2	4	Bismuth	Bi	83	209
Lithium	Li	3	7	Polonium	Po	84	210
Beryllium	Be	4	9	Astatine	At	85	211
Boron	B	5	11	Radon	Rm	86	222
Carbon	C	6	12	Francium	Fr	87	223
Nitrogen	N	7	14	Radium	Ra	88	226
Oxygen	O	8	16	Actinium	Ac	89	227
Fluorine	F	9	19	Thorium	Th	90	232
Sodium	Na	11	23	Protactinium	Pa	91	231
Magnesium	Mg	12	24	Uranium	U	92	238
Aluminium	Al	13	27	Neptunium	Np	93	237
Silicon	Si	14	28	Plutonium	Pu	94	239
Phosphorus	P	15	31				
Sulphur	S	16	32				
Chlorine	Cl	17	35				
Argon	Ar	18	40				

(Atomic weight given for Neptunium is that of isotope of longest life.)

In the notation used below the numeral below the symbol for the element is the atomic number, and that above the symbol is the atomic weight. The atomic number is the number of protons in the nucleus. The atomic weight is the sum of the number of protons and neutrons in the nucleus.

TABLE VI. 3. ELEMENTS AND THEIR SYMBOLS

Element	Atomic charge number of protons in nucleus, Atomic number	Number of neutrons in nucleus	Atomic weight number of protons and neutrons in nucleus	Protons, symbol, and neutroas and protons in nucleus
Hydrogen	1	0	1	$_1H^1$
Hydrogen Deuterium	1	1	2	$_1H^2$
Hydrogen Tritium	1	2	3	$_1H^3$
Helium	2	2	4	$_2He^4$
Helium	2	3	5	$_2He^5$
Lithium	3	3	6	$_3Li^6$
Lithium	3	4	7	$_3Li^7$
Lithium	3	5	8	$_3Li^8$

TABLE VI.4. BULLETS USED IN SPLITTING ATOMS

Bullet	—	Symbols	Effect Produced
Proton	Hydrogen nucleus	${}_1H^1$	Hydrogen ions, produced by the cyclotron or Van de Graff generator.
Neutron	Uncharged particle	${}_0n^1$	Made by bombarding beryllium or boron with alpha particles.
Deuteron	Heavy Hydrogen	${}_1H^2$	Heavy hydrogen ions, produced by the cyclotron or Van de Graff generator.
Alpha Particle	Helium Nucleus	${}_2He^4$	Helium ions, produced by the cyclotron or Van de Graff generator. Also emitted naturally from radium.
Beta Particle	Electron	${}_{-1}e^0$	Emitted naturally from radium. Also produced by Betatron.

SOME MILESTONES IN THE RELEASE OF NUCLEAR ENERGY

600 BC Thales knew that objects could be electrified.

400 BC Democritus thought matter to be composed of invisible indestructible bits of matter.

1800 AD Dalton as a result of quantitative experiments theorized that all matter is made of tiny particles which he called atoms; the atoms of the same elements are alike; atoms of one element differ from atoms of another element; chemical reactions are reactions between these indivisible atoms.

1860 Sir William Crookes produced a visible discharge which he called cathode rays. J.J. Thompson studying cathode rays determined:

1. Cathode rays are a stream of electrons with terrific velocities.
2. These electrons are the same no matter what element is used as their source (as the cathode).
3. Some of the tiny particles from which everything is made must be electrons.

1895 Wilhelm Conrad Roentgen found that X-rays are given off when cathode rays strike a suitable target.

Robert A. Millikan measured the electron's charge and its mass. He found it to be about 1/1840 of the mass of the lightest element, hydrogen.
9×10^{-27} grammes or .000,000,000,000,000,000,000,000,009 grammes.

1896 Henry Becquerel noticed that photographic plates were bleached with uranium.

1898 Curies discovered radium; studied its disintegration with a spinthatiscope, found three types of rays:

Alpha particles	—	ionized helium atoms
Beta particles	—	electrons
Gamma rays	—	electromagnetic radiation (like hard X-rays).

1903 Explanation—Radioactivity—Rutherford and Soddy.

Radium atom weighs 226 times more than a hydrogen atom. An alpha atom weighs four times as much as a hydrogen atom. When radium atom shoots an alpha particle, it loses four units and a new atom with atomic weight 222 is formed. The atoms of Dalton and Boyle are composed of still smaller particles,.

1905 Einstein—Relativity Theory.

$E=MC^2$ where E is energy in ergs, M is mass in grammes, and C is velocity of light—186,000 miles per second.

1911 Rutherford—Description of nucleus—with Spinthatiscope, gold foil, fluorescent foil, and microscope. Atom has positively charged nucleus. This nucleus is so small that if it were enlarged to the size of a marble, the atom would have a diameter the length of a football field.

1913 Nature of atom—Niels Bohr.

How are nucleus and electron kept apart? If proton is enlarged to the size of a marble, then electron would be 150 feet away. Force of attraction between proton and electron on this scale would be 400 million tons. The electron must be kept from the proton by 'centrifugal' force. Atoms consist of miniature solar systems with electrons spinning around positively charged nucleus at fantastic speeds—so fast that they seemingly form a shell of electrons around the nucleus.

1918 Rutherford succeeded in changing nitrogen to oxygen by bombarding it with helium atoms:

$${}_2He^4 \quad \text{plus} \quad {}_7N^{14} \quad \text{gave} \quad {}_8O^{17} \text{ and } {}_1H^1$$

1932 Chadwick identified the neutron:

$${}_2He^4 \quad \text{plus} \quad {}_4Be^9 \text{ gave } {}_6C^{12} \text{ and } {}_0N^1$$

Concept of matter now is one consisting mainly of protons, neutrons, and electrons.

Fermi suggested that neutrons would be especially effective particles to use as transmuting agents for they would not be repelled by the nucleus and they have sufficient mass to carry plenty of energy.

Irene Curie tried Fermi's suggestion and obtained some elements of lower atomic number.

1932 Cockcroft and Walton experimentally proved Einstein's prediction of the equivalence of mass and energy.

${}_1H^1 + {}_3Li^7$ gave $2_2\,He^4$ and 17 million electron volts of energy.
1.0076 7.0165 8.0056 ·0185 (mass to energy).

(An electron volt is the energy an electron receives when it falls through an electrical potential of one volt.)

1938 Hahm—Discovery of fission

$${}_{92}U^{235} + {}_0n^1 \rightarrow \text{Two elements} + \text{neutrons} + \text{KE}$$

Isolation method: ${}_{92}U^{235}$ from ${}_{92}U^{235}$

1. Thermal diffusion
2. Porous barrier
3. Electromagnetic separation.

Production of new fission element$_{94}$ Plutonium ${}_{94}Pu^{239}$

$${}_{92}U^{238} + {}_{0}n^{1} \rightarrow {}_{92}U^{239}$$
$${}_{92}U^{239} \rightarrow {}_{93}Np^{239} + {}_{-1}e^{0}$$
$${}_{93}Np^{239} \rightarrow {}_{94}Pu^{239} + {}_{-1}e^{0}$$

Major Concept 10: The atomic energy in radium is given off in flashes for thousands of years.

Concept 10-a,b (p. 70): (a) Each atom has one flash of atomic energy.
(b) Different atoms flash yielding energy at a predictable rate.

To show that radiation occurs in separate flashes, examine with a hand lens a luminous hand on a watch or clock. You should be able to distinguish the individual flashes as radiation from disintegrating atoms strike the luminescent point.

To visualize the make up of the nucleus of atoms, make models of the nucleus of several atoms. Let dark peas represent the neutrons in the nucleus, and light beans represent the protons in the nucleus.

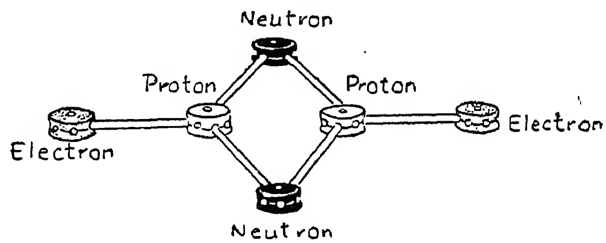


Fig. 99 a. Model of a helium atom.

Major Concept 11. Scientists have found a method of making a vast number of atoms give off their energy all at once yielding an enormous amount of light and heat.

Concept 11-a,b (p. 70): (a) When several small pieces of Uranium 235 or plutonium are brought close together under certain conditions, they set off a quick atomic flash.
(b) Neutrons from the flash cause nearby atoms to give off their energy, which in turn produce other neutrons. These in turn cause still other atoms to give off energy. This is called a chain reaction.

When a neutron strikes an unstable nucleus of ${}_{92}U^{235}$ or ${}_{64}Pu^{239}$ for example, it causes the atom to split into two lighter atoms. Thus any of the following reactions might occur. Calculate how many neutrons might be released in each of the examples given, which neutrons might strike other nuclei of other unstable atoms and in turn cause them to split.

$${}_{92}U^{235} + {}_{1}N^{1} \rightarrow {}_{36}\text{Krypton}^{84} + {}_{56}\text{Barium}^{138} + (?)\ {}_{1}N^{1}$$

$${}_{92}U^{235} + {}_{1}N^{1} \rightarrow {}_{38}\text{Strontium}^{98} + {}_{54}\text{Xenon}^{132} + (?)\ {}_{1}N^{1}$$

$${}_{94}Pu^{239} + {}_{1}N^{1} \rightarrow 2\ {}_{47}\text{Silver}^{107} + (?)\ {}_{1}N^{1}$$

$${}_{94}Pu^{239} + {}_{1}N^{1} \rightarrow {}_{50}\text{Tin}^{120} + {}_{44}\text{Ruthenium}^{102} + (?)\ {}_{1}N^{1}$$

$${}_{94}Pu^{239} + {}_{1}N^{1} \rightarrow {}_{42}\text{Molbdenum}^{98} + {}_{52}\text{Tellurium}^{52} + (?)\ {}_{1}N^{1}$$

Major Concept 12. Scientists can increase or decrease the speed of this chain reaction.

Concept 12-a,b (p. 70) : (a) In z bomb, the chain reaction is made to occur rapidly.
(b) Chain reactions can be slowed down so that the heat can be used for making steam to drive a turbine.

A reactor is a machine in which a *chain reaction* is slowed down.

Find pictures of an atomic furnace or magazine articles telling how a reactor works. After studying about the way such a furnace works, explain its operation to others.

Major Concept 13. Scientists have discovered many uses of atomic energy.

Concept 13-a, b (p. 71) : (a) Since atomic fuels give off large amounts of energy for their weight, a very small amount of fuel can run an engine for a long time.
(b) Atomic energy may eventually lower the cost of electricity also. It may be used where other sources of power are not available.

The big advantage of nuclear fuels over conventional fuels is that nuclear fuels yield such a vast amount of energy in comparison to that from conventional fuels. It has been estimated that 10 kilograms of uranium can provide enough power to light 30,000 homes for a whole year. In reactors, nuclear fuels can be used to produce steam, which by means of turbines operate huge electric generators just as in the case of coal or oil burning power stations.

Find out about the use of nuclear power plants from magazine articles or other sources and plan to share your findings with others. What are the particular advantages of nuclear fuels for driving ships? Submarines? Lighting cities?

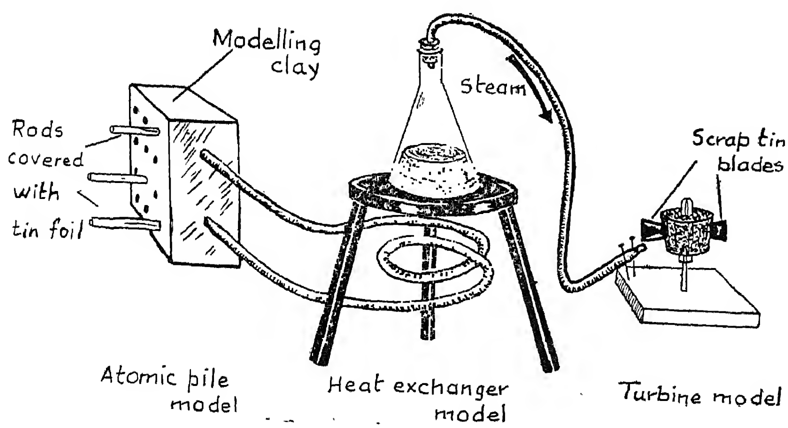


Fig. VI. 99 b. Model reactor.

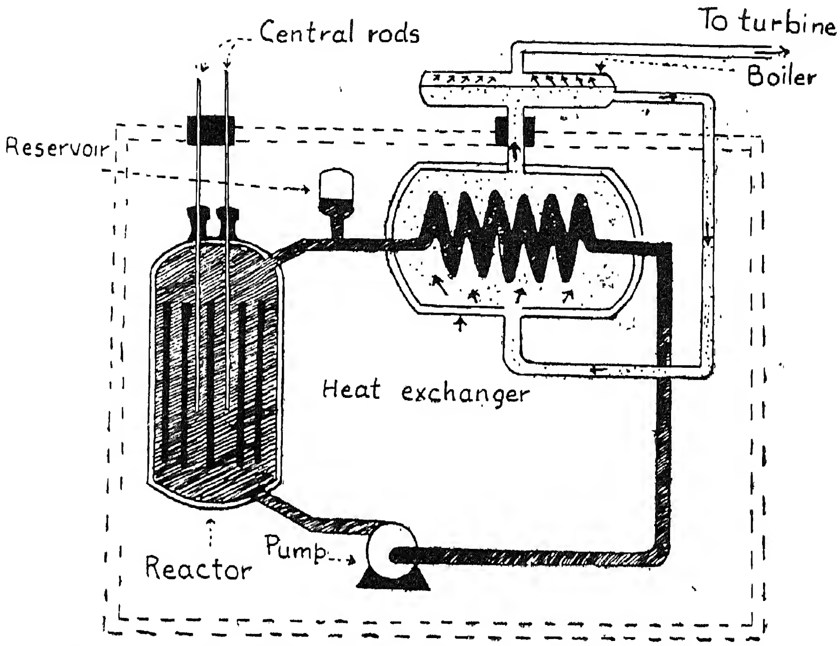


Fig. VI. 99 c. Atomic reactor.

Concept 13-c (p. 71): Scientists have made life easier by improving health, increasing food production and developing automatic manufacturing.

Investigate the various ways that scientists have used their knowledge of atomic energy to benefit mankind. In what ways has man used this knowledge in controlling illness? In industrial research? In increasing food supply?

Concept 13-d (p. 71): Many scientific discoveries can be good or bad for human beings, depending on how the discoveries are used.

Find out about and discuss the ways that man can use atomic energy to promote peace, and the terrible consequences, should it be used in war. Discuss ways to extend the peaceful uses of atomic energy and to limit the uses in war.

Report on cyclotron, bevatron, cosmotron, 'fall-out', new uses of atomic energy, diminishing reserves of fossil fuels, and current research in this field.

ELECTRICITY

Major Concept 1. Electricity may be measured in various ways.

Concept 1-a, b, c, d (p. 71) : (a) The amount of current flowing in a circuit is measured in *amperes*.
(b) The electrical pressure of a current flowing in a crcuit is measured in *volts*.
(c) The resistance of the circuit to the flow of current is measured in *ohms*.
(d) The *amperes* of a current flowing in a circuit are directly proportional to the *volts* and inversely proportional to the *ohms*. $A = \frac{V}{O}$.

1. To measure the quantity of current flowing in a circuit, an ammeter is connected in series with the resistance in a circuit. An ammeter is an instrument used to measure the current flow in an electrical circuit. In the series circuit, the current is the same throughout, so the ammeter can be inserted anywhere in series. In connecting meters in a circuit, be sure the positive terminal of the meter is connected to the positive side of the circuit.

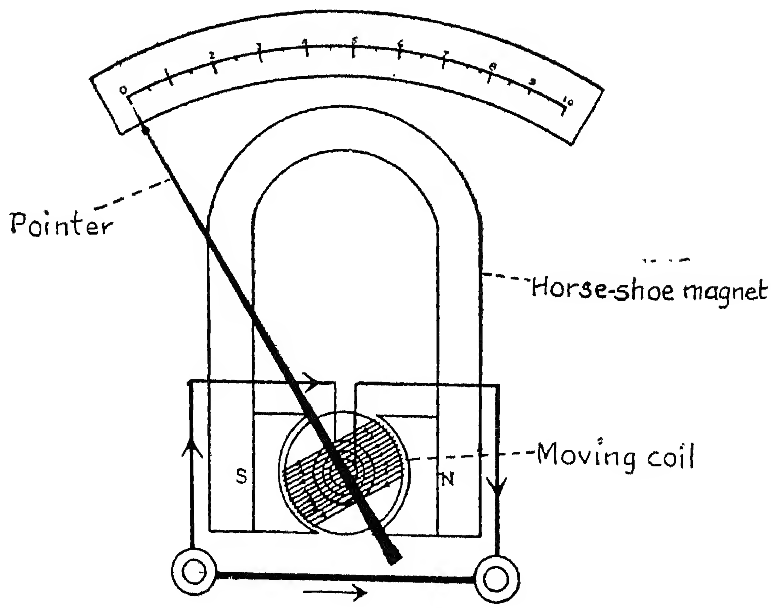
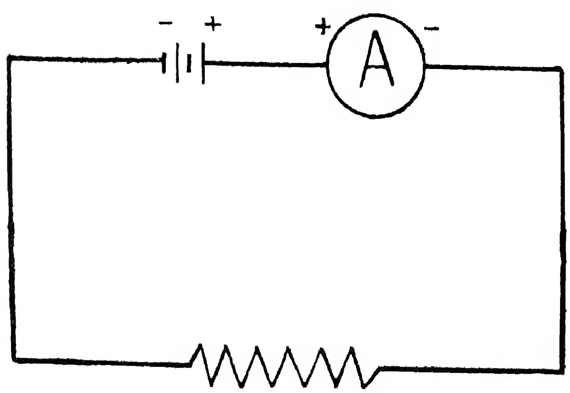


Fig. VI. 100 a. Ammeter, cut away.



All the current that flows in the circuit flows through the ammeter.

First connect the wires of the circuit so that current flows only from one cell. Then connect the wires so that current flows from both cells. How does the number of cells connected in the circuit affect the *amperes* of current flowing in the circuit?

Fig. VI. 100 b. Current is measured by placing ammeter (A) in the circuit.

2. A voltmeter measures the voltage or the potential difference between any two points of a circuit to which it is connected. The voltmeter is always connected across the circuit or in parallel with the part of the circuit whose potential difference you want to measure (Fig. VI. 101).

To measure the difference in electrical pressure in volts, produced by one or two cells in a circuit, connect the voltmeter in parallel with the dry cell or cells as shown here.

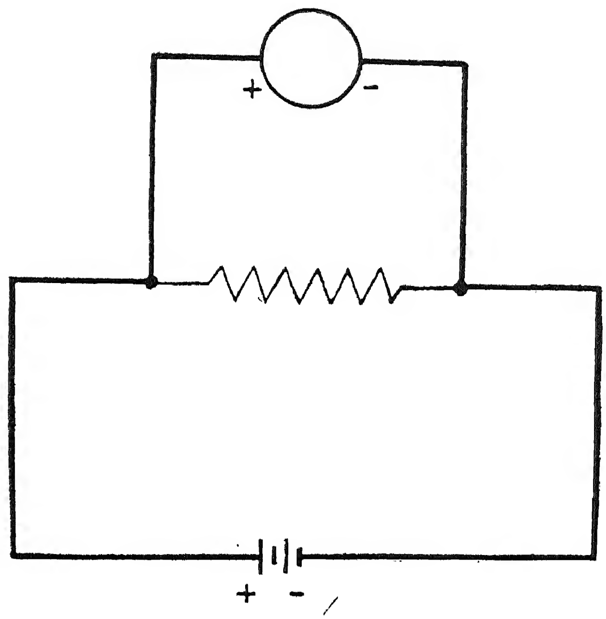


Fig. VI.101-b. The voltage drop in a resistance is measured by connecting a voltmeter (V) accross the resistance.

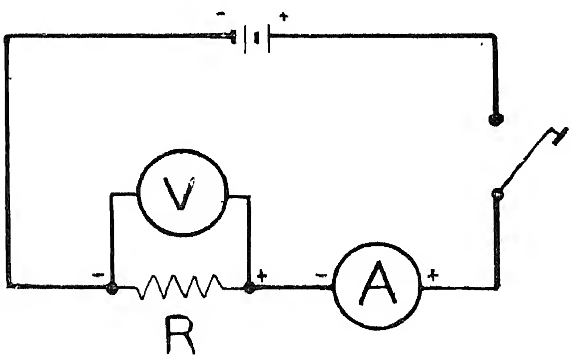


Fig. VI.102. The voltmeter measures the voltage drop across the resistance and the ammeter measures the circuit through it.

First connect it across one cell and then across the two cells as shown. Compare the voltage produced by one cell with that produced by two cells. Note the loudness of the bell. Develop the concept that, the greater the voltage, the greater the current.

To measure the voltage drop across resistors in a circuit, connect the voltmeter in parallel with first one resistor or lamp bulb and then with both resistors or lamp bulbs as shown in illustration. Lamp bulbs may be used as resistors.

How does the voltage drop across one bulb compare with that across two bulbs.

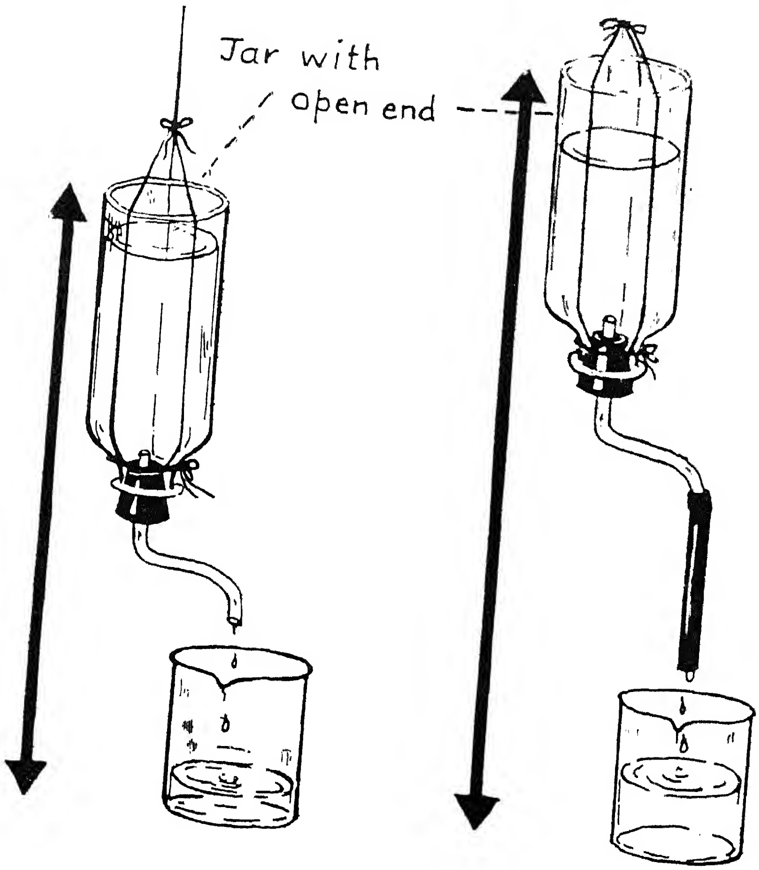


Fig. VI.103. Analogy between water and electricity with regard to pressure, current, and resistance.

3. Fill a suspended vessel with water. Let the water from the vessel flow through a tube into a beaker. Measure the amount of water collected in the beaker per minute.

Add a rubber tube as shown in the figure and raise the level of the suspended vessel. Measure the amount of water collected in the beaker per minute.

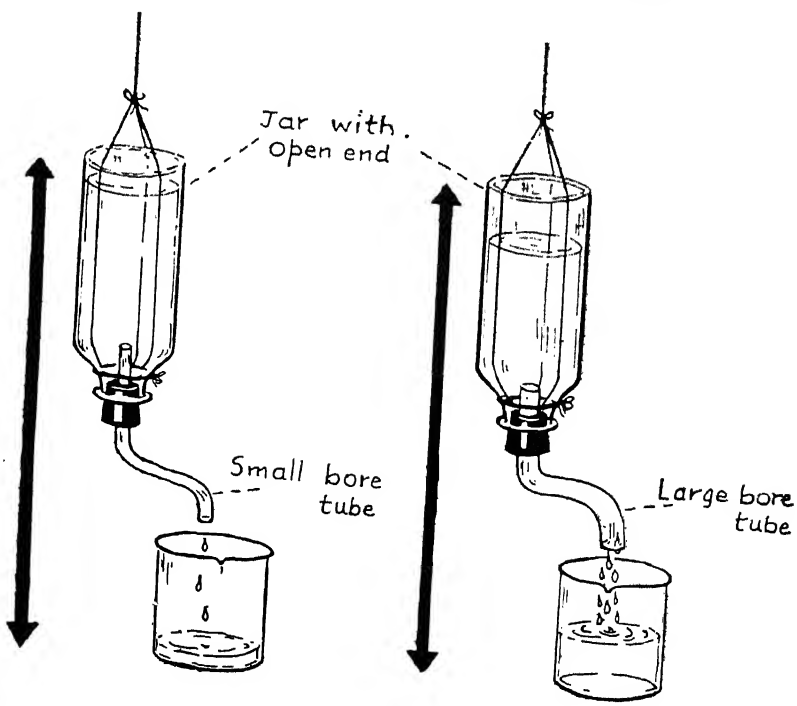


Fig. VI. 104. Analogy between size of bore of water tubes and size of wires carrying electrical current.

Discuss the results and deduce that the amount of water collected per minute increases as the water-head is raised (Fig. VI. 103).

Use this set-up for analogy in electric circuits. The water-head in this experiment corresponds to electric pressure in electric circuits and is measured in volts (as water head may be measured in meters). The amount of water collected per minute corresponds to the number of electrons passing per unit or to electric current which is measured in amperes (as volume of water is measured in cc).

4. Repeat the experiments described above, keeping the same water-head, but using connecting tubes of different bores. Notice that the larger the bore, the greater is the amount of water collected. Develop the idea that the connecting tubes in these experiments correspond to the connecting wires in electric circuits. Tubes of smaller bores do not allow water to pass through them as fast as the tubes of bigger bores. In other words, thinner tubes offer more resistance to the flow of current. Extend the analogy to the flow of electric current. Thinner wires also offer more resistance to the flow of electric current than thicker wires. (Compare Figs. 104 and 105).

5. Make the connections as shown in Fig. VI. 105. Compare the amperes of current flowing in circuit A with those flowing in B. Account for any difference.

6. Arrange a bell circuit with a stretched steel spring as a resistor. Touch the loose end of the wire coming from the electric bell to different parts of the stretched steel spring. Notice the effect on the loudness of the bell. Develop the idea that the longer and thinner the wire in the circuit, the greater is the resistance and the less is the current. Resistance is measured in ohms. The ohm is a fixed amount of resistance or opposition to the flow of circuit.

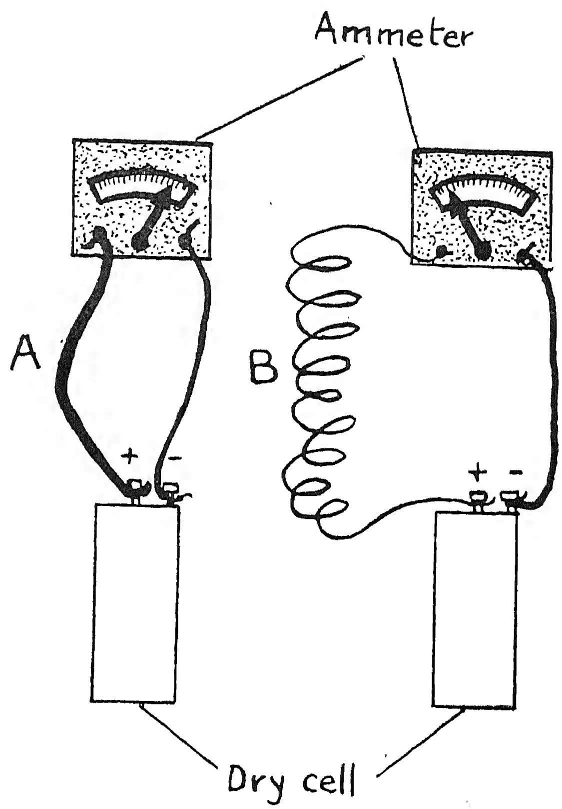


Fig. VI.105. Thinner wires offer more resistance than thicker ones.

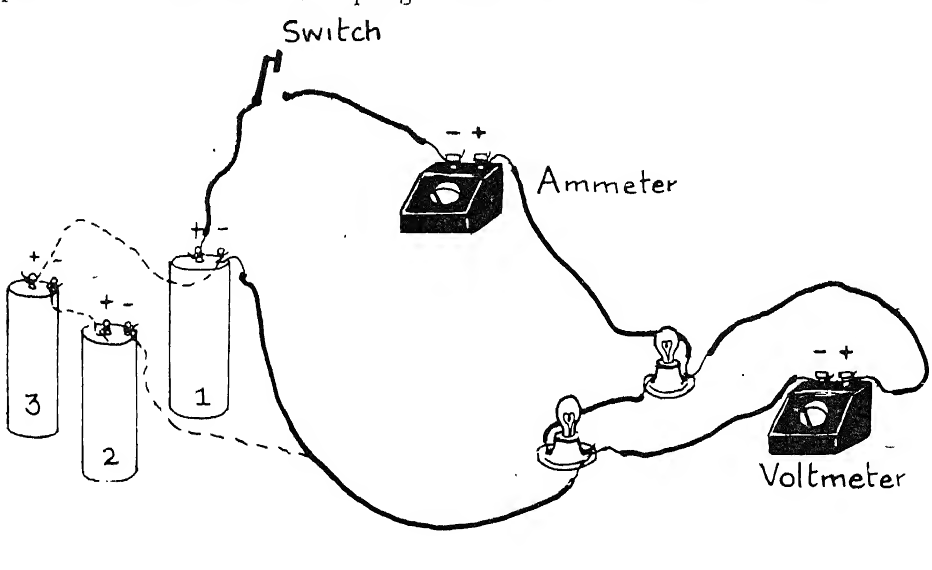


Fig. VI.106. Measuring resistance in ohms.

7. To measure the ohms resistance in the flash light bulbs arrange a circuit as in Fig. VI. 106. Take readings of the volts and the amperes when 1, 2 and 3 dry cells are connected in the circuit. Calculate the ohms resistance using the formula A=V/O

What is the resistance of the two lamps in ohms?

Concept 1-e, f (p. 71) (e) The power flowing in a circuit is measured in *watts*. One watt is equal to a current of one ampere flowing through a difference of one volt. $W = A \times V$. One kilowatt is 1000 watts.
(f) The electrical energy consumed is measured in kilowatt-hours. One kilowatt-hour is a kilowatt of power flowing for one hour.

1. Calculate the *watts* of energy flowing in the circuit 1-c above when all three cells are connected in series, using the formula $W = A \times V$. The watt is the metric unit for measuring electrical power. In fact, the watt is a measure of power in any form of work.

2. Ask the pupils to gather information on wattages of a number of devices used in homes such as electric bulbs 60, 75 or 100 W. or an electric iron (over 500 watts). Discuss the meaning of statements like—a particular brand of electric fan is of 60 watts.

3. Motivate the pupils to gather electric bills and study them. How many 'units' have they been using per month on an average? How much is one unit of electricity?

The unit of energy is the kilowatt-hour. This represents the work done when one kilowatt of power is used in one hour. The electric meter records the number of kilowatt-hours used.

4. Make a demonstration kilowatt-hour meter board for use in class. Cut a piece of fiber board 84 cm. long and 30 cm. high. Cover it with white paper. Measuring from the left hand of the board, drill four 0.9 cm holes; one at 12.7 cm, the second at 31.1 cm, the third at 52 cm. and the fourth at 72 cm. Using these holes as centres, draw 4 circles, each with a radius of 9 cm. Numbers may be painted on the paper or cut from a calendar and pasted on.

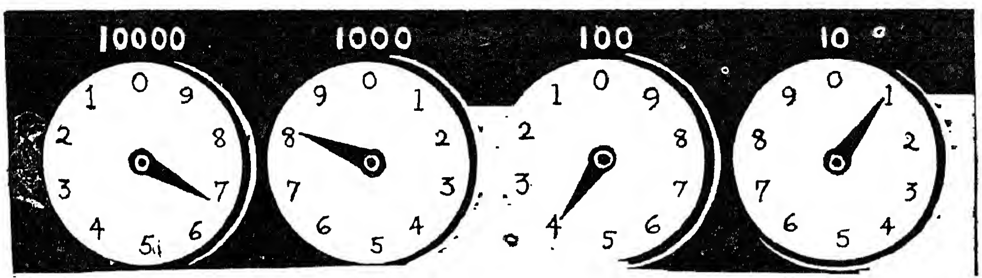


Fig. VI. 107. Meter board.

Simple pointers, using parts of a wooden construction set, can be made for each hole as shown in the diagram.

Set up two separate readings on the board for the pupils to record. Ask them to find the difference between the readings and calculate the cost for that number of kilowatt-hours at the prevailing rates of the area.

5. Examine the kilowatt-hour meter at home or at school and find out how it measures the electrical energy used.

Major Concept 2. Currents are induced in electrical circuits, whenever there is relative motion between a conductor and a magnetic field. Several kinds of devices are used to induce electrical currents.

Concept 2-a (**p. 71**)**:** In a magneto a coil of wire is rotated between the poles of permanent magnets. A magneto generates an alternating current.

To show how a magnet may be used to produce electricity:

1. Make a coil of 100 turns of a No. 30 or No. 40 copper wire and tie threads around the rim at several places to hold the coil. Connect the two ends of the coil to the galvanometer.

Take a magnet, dip one of its ends inside the coil and watch the pointer of the galvanometer. Keep the magnet still inside the coil for a few moments. Then take it out. Watch the pointer of the galvanometer again. What happens to the pointer of the galvanometer? (Refer to Fig. VI.49).

Keep the magnet still and move the coil over one of its ends and watch the pointer of the galvanometer. Keep the coil still for a few moments. Then remove it while watching the pointer of the galvanometer.

What happens to the pointer of the galvanometer? Why?

Repeat the experiments by moving the magnet or the coil in and out first slowly and then quickly while watching the galvanometer pointer. What happens to the pointer of the galvanometer?

Repeat the experiment with a coil of smaller turns, say 50. Move the magnet or the coil in and out as quickly as before, while watching the galvanometer point. What happens to the pointer of the galvanometer? Why?

(The amount of current induced is dependent upon the speed of relative motion, the number of coil turns, and the intensity of the magnetic field.) Is this what have you determined by your experiments?

2. Look at the simple type of electric generator, *a magneto.* It has several U-magnets placed next to each other with like poles together. (Why?) Since magnets provide the magnetic field they are called *field magnets.* Between their poles is a coil with many turns of wire wound around an iron core. (Lines of force pass through iron more easily than through air. So an iron core provides more lines of force right where they can be cut by the wires in the coil.) This is called the *armature.* The armature is turned around with a crank. Electricity flows through the wires. Two insulated rings (called 'collector rings') are mounted in the shaft and each end is connected to one end of the revolving armature coil. Little strips of thin copper or copper gauze or carbon called *brushes* press against each ring. They lead the electric current out of the armature. (In some magnetoes one end of the armature is grounded.)

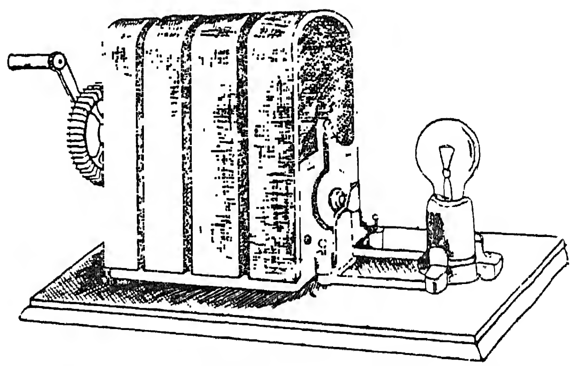


Fig. VI. 108 a. Magneto with four field magnets. Bulb lights up when crank is turned.

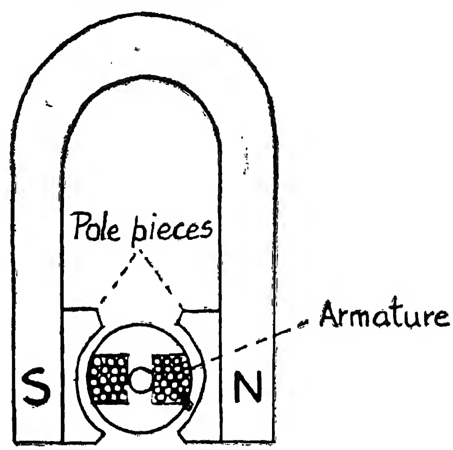


Fig. VI. 108 b. Cut away of magneto.

Concept 2-b (**p. 72**) **:** In a dynamo or a generator, a coil of wire is rotated in the field of an electro-magnet or the electro-magnet is rotated in a coil of wire. An alternating current is generated in the coil and this current may be converted into a direct current by means of a split ring commutator.

(1) To increase the intensity of a magnetic field in a generator we can replace the permanent magnets of a magneto with electro-magnets, and so generate a larger current. 'Dissect' an old automobile generator; observe the fixed or field coils and the rotating coils, or armature. The armature is rotated in the field of the electro-magnet. It is not only possible for electricity to produce magnetism, but magnetism can produce electricity from mechanical energy.

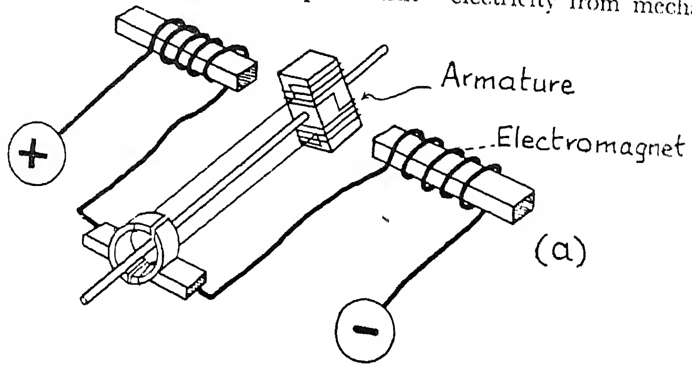


Fig. VI. 109 a. Series wound.

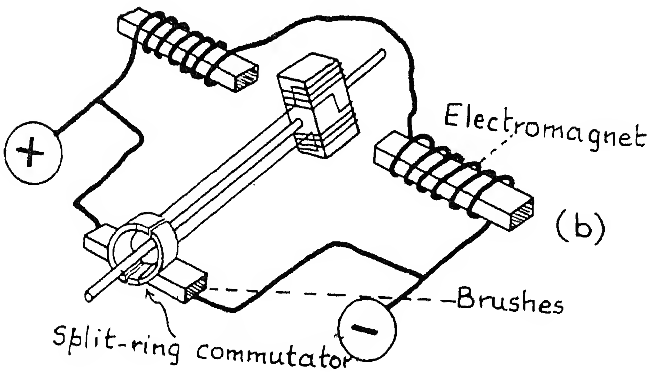


Fig. VI.109 b. Parallel wound.

(2) Look at the dissected automobile dynamo (generator). Observe the copper commutator segments. The two diametrically opposite segments are connected to each coil. How many segments are there? How many coils are there? Why are there so many coils?

Concept 2-c (**p. 72**) **:** In a magneto or a dynamo, the induced current is such that it builds up a magnetic field that opposes the motion. In this way, mechanical energy is converted into electrical energy by the use of magnetism.

Have someone turn the crank of the magneto with no bulb (load) connected. Then, while he is still cranking it, switch in a load such as an electric light bulb (Fig. VI.108 a).

What happens?

Why do you experience sudden difficulty in turning?

Mechanical energy is used to produce electrical energy. As the amount of electrical energy being used increases, the required amount of mechanical energy also increases.

Concept 2-d (p. 72): In a transformer, an alternating current in the primary coil produces a moving magnetic field in a secondary coil, thus inducing a current in the secondary coil.

To demonstrate that there is a moving magnetic field produced by the alternating current in a wire from one that no longer works. Or examine the illustration given here.

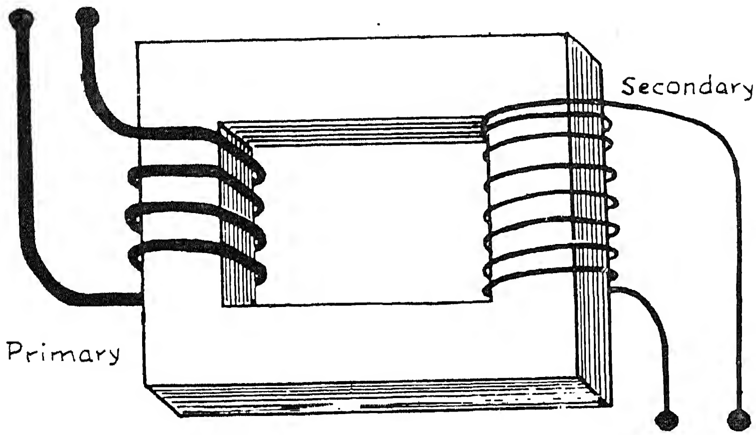


Fig. VI.110. Step-up transformer.

transformer, bring a small sheet of iron (from a tin can or otherwise) or a compass needle against a small transformer.

This sheet of iron should be attracted to the transformer by the magnetic field of the transformer. When the transformer is connected to the alternating house current the sheet of iron should vibrate each time the current reverses and in turn reverse the magnetic field. The 100 vibrations per second should clearly demonstrate that there is a moving magnetic field in the transformer.

To see how a transformer is made, unwind the

Each time the direction of current is reversed, it reverses the magnetic field. The moving magnetic field generates a current in the secondary coil. The voltage in the secondary circuit depends upon the number of turns of wire compared to the number of turns in the primary. If there are 2 x as many turns in the secondary coil as in the primary coil, the voltage is twice as high in the secondary coil. If there are $10x$, the voltage is ten times as high.

In a step-down transformer there are more turns in the primary coil than in the secondary coil (Fig. VI.117).

Concept 2-e (p. 72): In a coil, such as the induction coil used in the ignition system of an internal combustion engine, a low voltage current from a storage battery is interrupted thus moving a magnetic field around the primary coil. This moving magnetic field induces a current in the secondary coil.

1. The induction coil of an automobile operates exactly in the same way as a step-up transformer with the exception that there is an interrupted direct current flowing in the primary circuit and an interrupted direct current flowing in the secondary circuit. When the flow of current is

suddenly stopped in the primary circuit, the magnetic field in the coil collapses. This moves the magnetic field through the coils of wire in the secondary circuit and so induces a current in them.

To demonstrate the operation of an induction coil, procure one from an old automobile—also procure a timer with breaker points and condenser and rig it up so that a spark will jump a gap when the primary circuit is opened in the timer.

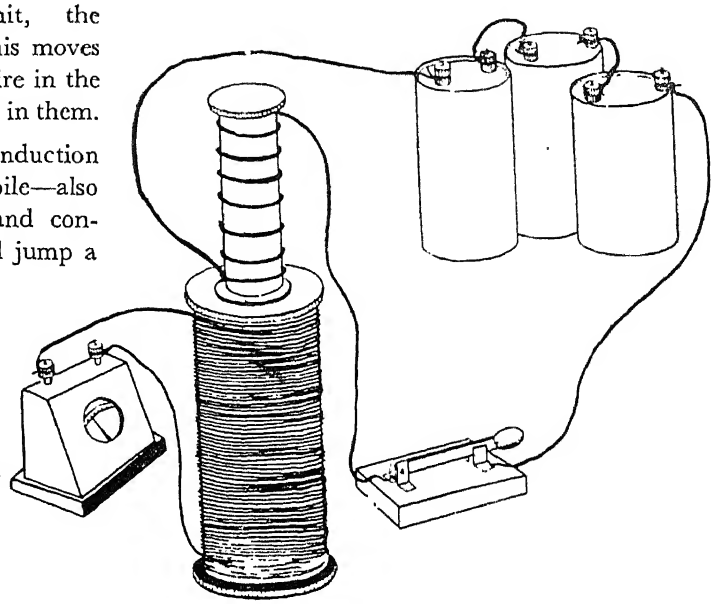


Fig. VI.111. How an induction coil works.

To see how a coil generates an electric current, place an electro-magnet inside a coil of wire connected to a galvanometer. Then open and close the switch in the primary circuit and note that a current flows in the secondary circuit of the coil. Does it flow when the current is on in the electromagnet? When it is turned off? When the current is turned on? Turned off? How is the current generated in the coil?

What kind of energy is converted into the electrical energy which flows in the coil?

A transformer works like a coil, but operates on alternating current in the primary circuit instead of on an interrupted direct current.

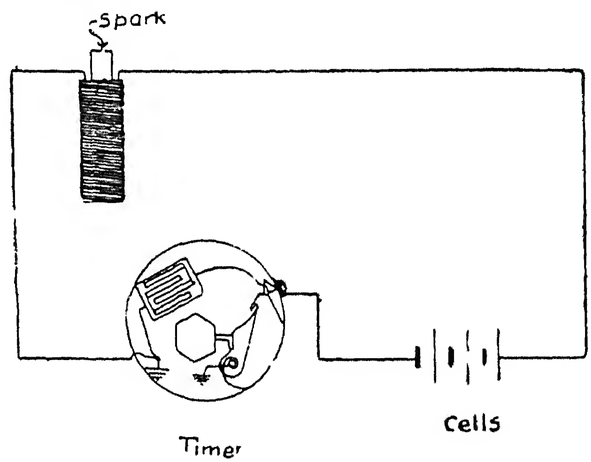


Fig. VI.112. As the timer opens the battery circuit, a spark jumps the gap in the coil circuit.

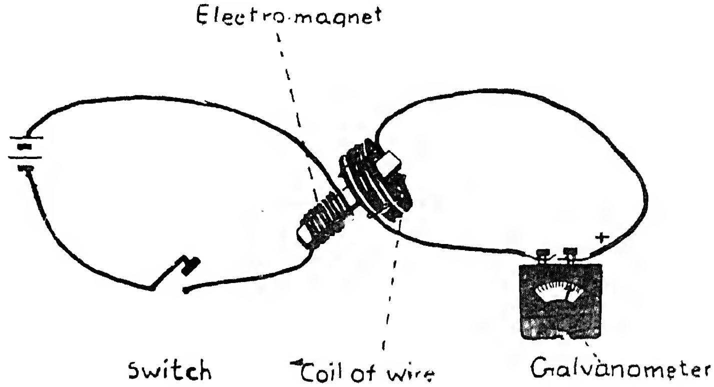


Fig. VI.113. How an induced current is generated.

Major Concept 3. A condenser is a device which permits electricity to be temporarily stored and then quickly discharged.

Concept 3-a (p. 72): In a condenser two metal plates are separated by a thin insulator. Electric charges on one plate affect those on the other plate.

An early form of a condenser was the Leyden jar. It consists of a glass bottle with a conductor on the inside and on the outside of the jar. For this, tin or aluminium foil may be used as the conductor.

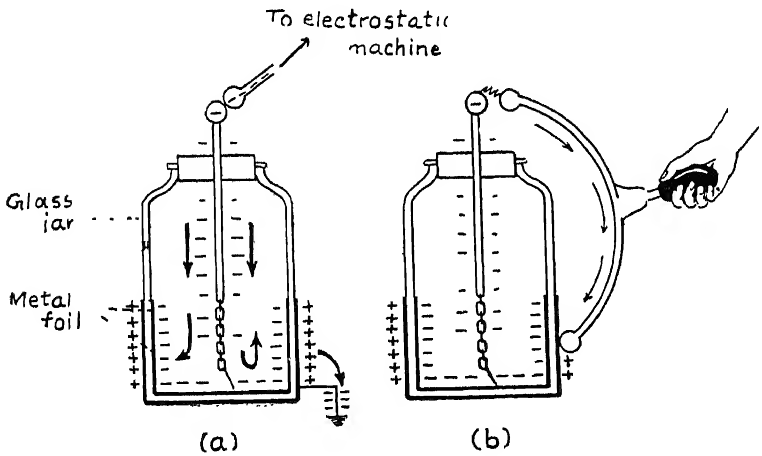


Fig. VI.114. A Leyden jar being charged in (a) and discharged in (b).

A Leyden jar may be quickly charged by connecting the centre terminal to an electrostatic machine, and the outside grounded on a wire connected to a water pipe. It may be more slowly charged by repeatedly rubbing a hard rubber or plastic rod with wool or fur and repeatedly adding the charges to the centre terminal. Try making one and charging it. See how long a spark you can get.

Other materials than glass may be used as insulators such as mica, rubber, plastic or air between the conductors. Condensers may be made in different shapes, and they may be of fixed or of variable capacity.

The capacity of a condenser

(a) depends directly on the area of the plates,

(b) depends directly on the voltage across the plates, and

(c) is inversely proportional to the distance between the plates.

Perhaps you can make some home-made condensers and test each of these characteristics.

If a Leyden jar is not at hand, you may want to have one made by students as a project. They can pour aluminium paint into a milk bottle and quickly pour it out again so that the inner surface is coated with aluminium. Wipe off the paint from the inner walls about an inch from the mouth of the bottle. Then paint the outer surface of the bottle with aluminium paint within an inch of the top. Or you may prefer to coat the outer and inner walls of a wide-mouthed jar with shellac and then line and coat the jar with a layer of aluminium foil. Stand a clean bare copper wire inside the bottle or jar as an internal connection; stand the bottle on a piece of bare copper wire to make the external connection. You may want to make a top for the jar and a charging post as shown. An old electric switch pull chain makes an excellent inner contact.

First charge the Leyden jar by connecting the internal wire to an electrostatic generator. Try

using a home-made electrophorus (Fig. VI.48) for charging. Then disconnect the generator and discharge the jar with a non-conducting handle by first touching the outer surface and then bringing the other end of the loop near the internal connection. A spark will jump.

Concept 3-b (p. 72): A condenser across the breaker points controlling the current in the primary circuit of an induction coil stops the current quickly—thereby changing the magnetic field faster and inducing a higher voltage current in the secondary circuit.

1. To demonstrate the operation of a condenser which temporarily stores and quickly discharges electricity, set up an ignition coil circuit as shown below; then attach a condenser across the switch and note the differences in the intensity of the spark generated. (Procure an ignition coil from an old automobile.)

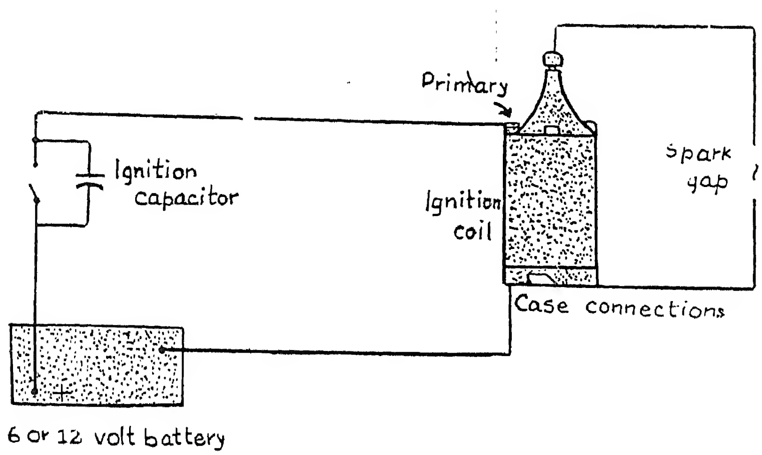


Fig. VI.115. An automobile ignition coil which produces high voltage sparks.

2. In the simple condenser shown in the above diagram, the ignition capacitor consists of two metal plates about 20 cm. square, nailed on two small blocks of wood. The metal plates can be brought very close together without touching. When the key is closed and opened, a spark occurs at the spark gap. Note the difference in the intensity of the spark produced when the metal plates of the condenser are close and when they are separated at different distances.

3. Fig. VI. 116 is a diagram of an ignition system of an automobile. Note how the condenser is connected across the breaker points of the timer. A current is induced in the secondary circuit of the coil each time the breaker points in the primary circuit open. Set a coil, timer, condenser, and spark plug from a car dealer and rig up a working demonstration of the ignition system of an automobile.

The illustration shows a simple ignition system with all the important parts named. When the ignition switch is turned on, the current from the battery flows through the breaker and primary windings of the coil. With the engine running, the cam (a raised part on the side of a shaft which pushes on an object to make it move away from the shaft when it rotates) revolves and opens and closes the breaker points at the proper time. Current flowing through the primary windings of the ignition coil builds up a strong magnetic field. When the cam opens the breaker points,

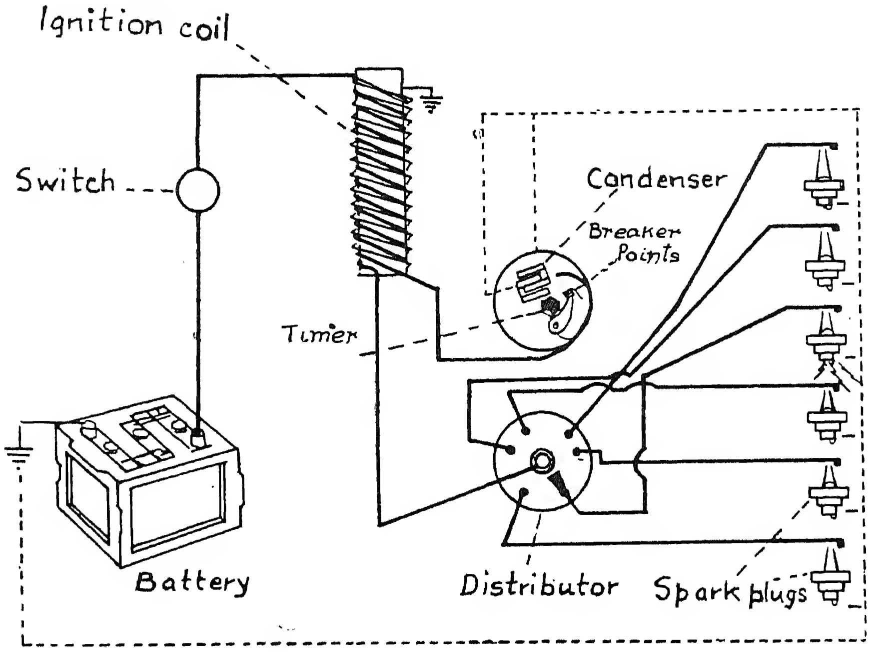


Fig. VI.116. Ignition system of an automobile.

the magnetic field collapses, cutting the many fine turns of the secondary windings of the coil. As much as 15,000 volts is induced in the secondary. The current from the secondary goes to the distributor where it is delivered to the spark plug of the proper cylinder at the right time. The high voltage causes the current to jump the gap of the spark plug producing a hot spark to ignite the gasoline-air mixture in the cylinder.

Major Concept 4. Electrical energy may be transmitted over long distances by sending a large amount of power (kilowatts) with a relatively small current (amperes). Watts=Amperes $\times$ Volts.

Concept 4-a,b,c (p. 72): (a) At the power plant, a current of usually 440 volts is generated. A step-up transformer then increases this voltage to 66,000, 1,32,000 or even 2,20,000 volts.

(b) High tension lines distribute the electricity to regional power stations where step-down transformers reduce the volts.

(c) Near each locality or small commercial consumer a step-down transformer further reduces the voltage to 440 volts or to 220 volts.

To show how a transformer may be used to change the voltage in a circuit, make several transformers and compare the voltage output when each is connected to a voltmeter. Make a common primary circuit by wrapping 50 turns of insulated wire—No. 20 aluminium or copper around a soft iron bolt. Then make four coils of insulated wire that may be slipped around the primary coil. These secondary circuits may be wrapped on cardboard tubes which may be slipped over the primary coil. Make one with 50 turns, one with 100 turns, one with 150 turns and one

with 200 turns. Then in succession see how much voltage is produced with each transformer when the current is turned off and on in the primary circuit (Fig. VI. 110).

11,000 to 2,200 volts, or from 1100 to 220. Likewise, if the primary of a transformer has 200 turns and the secondary has 2000 turns, then the voltage is stepped up 10 times—say from 220 to 2200 volts,

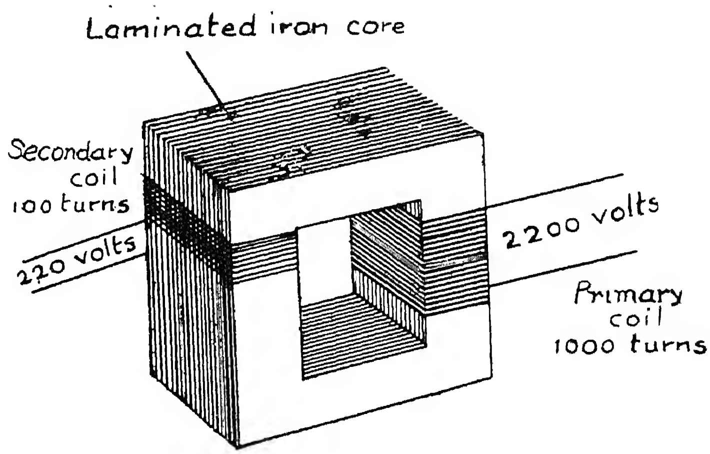


Fig. VI.117. Step-down transformer.

If the primary of a transformer has 1000 turns for example, and the secondary 200 turns, then the voltage is stepped down five times—say from or from 1100 to 11000 volts. The change in voltage is proportional to the number of turns of wire in the primary and secondary coils.

Major Concept 5. Electric motors are devices which convert electrical energy into mechanical energy.

Concept 5-a (p. 73): Electric motors are turned by the push and pull of the magnetic fields in the motor. The magnetism from the field magnets operates to turn the rotating magnets.

1. A simple demonstration to show how magnets may be used to push or pull can be made in the following way:

Magnetize two needles by stroking one end in one magnetic field; the other in the opposite field. Push a straight pin through a piece of cardboard all the way to the head. Take one of your needles and push it through a paper 4 cm × 2 cm. (Fig. VI. 118). Balance this on the point of the pin in the cardboard. Push the other needle through the eraser of a pencil. Hold the pencil so that the magnetized needle is just above the one on the paper strip. Slowly turn the pencil. As you turn it, you are also turning the magnetic field of the needle. What happens when you do this? The needle

in the paper is a rotor because it rotates. Demonstrate how the magnetism from the field magnets operates to turn the rotor. Study figure below.

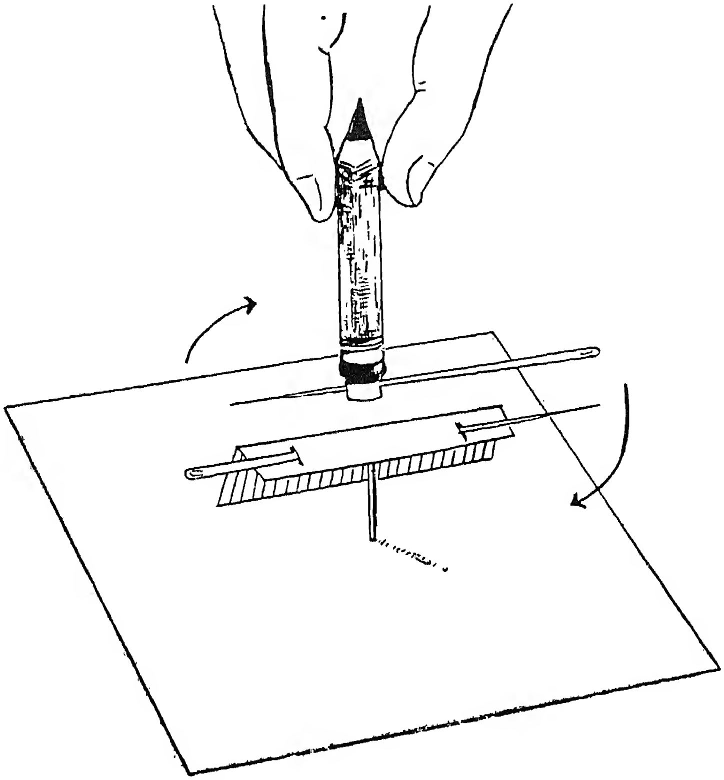


Fig. VI.118. Rotating magnetism.

2. Have numerous demonstrations of polarity of an electromagnet, the attraction of an electromagnet, how a rotating electromagnet works and causes something to turn. You may hang a bar magnet in a stirrup and while holding another magnet in your hand, move it so as to keep the suspended magnet turning by the reversal of the poles.

Concept 5-b (p. 73): A split ring commutator is used to reverse the direction of the current in the rotating magnet (armature) at the proper time to keep the field magnets pulling the armature magnets in the same direction at all times.

1. To show that magnetism can be reversed, use the materials of the experiment shown is Fig. VI.118.

a. Hold the pencil so that the eye of the needle is near the point of the rotor needle. What happens?

b. Hold the pencil so that the point of the needle is near the eye of the rotor needle. What happens?

c. Repeat the experiment holding the eye of one needle near the eye of the other. Then try both points. Recall the law of the magnets.

d. Now hold the pencil in an eye-to-eye position as in the next diagram. Lift the pencil and reverse it, bringing the point of its needle down to the eye of the rotor needle. Repeat the motions. If you time them properly, you can keep the rotor turning.

1. One way to keep an armature or rotor in rotation is to operate a switch by hand and so reverse the current.

Make a hand-operated reversing switch, if one is not available (Fig. VI.119). Trace the direction of the flow of electricity when the left side of the switch is closed and when the right side is closed. Test what you are doing with a magnetic needle.

An automatic reversing switch called a commutator can be made.

2. Show how a split ring commutator acts to reverse the current to keep the rotor (armature) turning. If you hold a magnetic needle or a compass near the poles of the rotor, you can find out where and when the reversal of polarity occurs.

A split ring commutator is a device for changing alternating current to direct current. The two halves of the split ring are insulated from one another and the shaft. A brush always touches each half. The negative brush leaves the negative segment and the postive brush leaves the postive segment at the instant the current reverses in the coil. The current is thus kept direct.

3. Build a home-made demonstration electric motor with materials available. The following plan may help you to do this.

One of the best devices to use both in stimulating an interest in and developing an under-

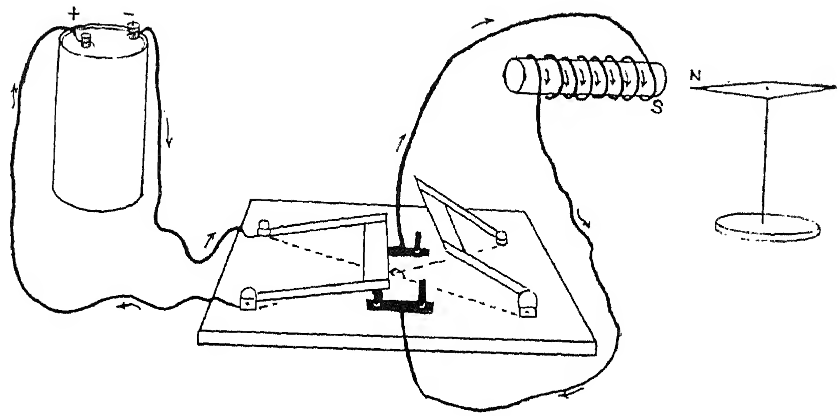


Fig. VI.119 A reversing switch with left side closed.

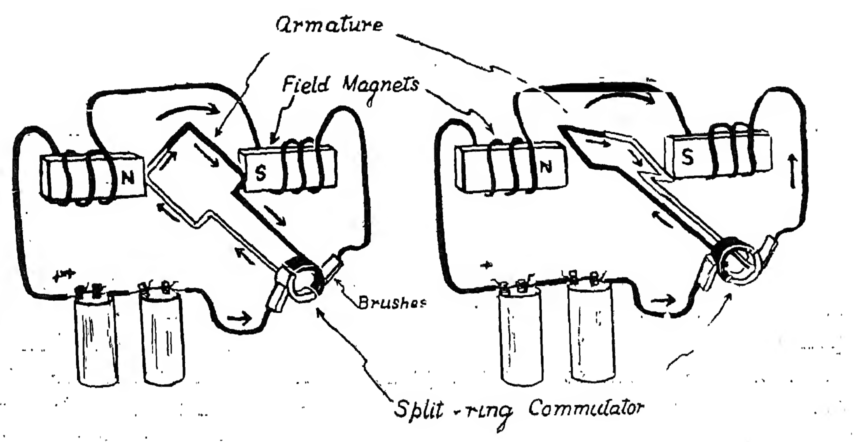


Fig.VI.120. A direct current motor showing a split-ring commutator which acts as a reversing switch.

standing of principles of magnetism and electricity is an electric motor.

A good home-made motor should be sturdy enough to run for hours without adjustment; be efficient, so that it does not discharge batteries too quickly; be large enough to see easily and also to enable one to test the magnetic poles with a compass; be so arranged that its direction of rotation can be reversed; and be rather easily constructed of relatively inexpensive materials. The motor described herein meets all these qualifications, being made entirely of scrap materials except for about a Rs. 5.00 worth of insulated bell wire. The iron core of the armature is made by rolling the metal from a tin can and making it flat with a hammer. The armature is supported on the point of a sharpened nail. A metal disc with a small dent in the centre, cut from a tin can, is used at the top of the spool as a low friction bearing. Side friction on the nail is limited by the use of a metal washer tacked to the bottom of the supporting spool.

Friction between the commutator and the brushes is reduced by having the commutator fit the curvature of the spool and by having the brushes very flexible so that they can be made to maintain a slight pressure on the commutator at all times.

A strong magnetic field is achieved by using a soft steel core both in the field magnets and in the armature. These are made by rolling up a section of a tin can and then flattening it out with a hammer. Then wrap many turns of wire on both the armature and the field magnet. Arrange to have the brushes always in contact with the commutator so that current is flowing through the wires at all times except for the brief instants when the commutator segments shift from one brush to the other.

As you know, the field magnets should be so wound that one exposes a north pole while the other exposes a south pole. The armature should be so wound that one end is a north pole while the other is a south pole. To achieve this, send the current in the wires around both ends of each magnet in the same direction. You will have no difficulty with the armature, but in wrapping the two ends of the field magnet exercise care to see that you wind the wire in the same direction you would if you were making a straight electromagnet, rather than a U-shaped one.

The connections at the ends of the wire are easily made. Fasten the two ends of the armature wire to the metal strips extending up from each brush by pressing the end of each metal strip over the end of each wire tightly with pliers. Fasten one end of the wire from the field magnet to the brush by wrapping the end around a nail and then driving the nail through the bottom of the brush into the wooden base. Fasten a lead wire to the other brush in the same manner.

To operate the motor, send current around the coils of the two field magnets, then in series through one brush to the commutator and armature, then back through the commutator and other brush to the battery. To reverse the direction of rotation, change the direction of current in the armature by changing the two connections either on the armature or on the brushes.

To construct this motor the following materials are needed:

- 4 dry cells or a storage battery
- 25 metres of insulated bell wire
- Several 5 kg. Dalda cans
- A slender nail about 7 cm. long
- A scrap of wood for base
- Small nails
- One empty thread spool
- A drill, hammer, tin strips (strips) and pliers will also be useful.

It is suggested that the following steps be followed in making the motor:

1. Prepare a wooden base about 15 cm. square.

2. Cut the metal pieces from 5 kg. Dalda cans. Roll one rectangular piece about 30 cm. long and 6-7 cm. wide, several times to form a small cylinder, and hammer it flat. Then bend it into a U-shape with the base of the U about 14-15 cm. and each leg of the U about 7 cm. These legs will be wound with wire to form the field magnets. Drill two small holes in the base of the U and through these drive nails to anchor

it to the wood base. Mark the centre of the U and drill a hole for the nail which will support the rotating armature. This hole should be drilled through the wooden base and should be somewhat smaller in diameter than the nail so that the nail will be held in place tightly. (See Fig. VI.121.)

serve as the metal cone of the rotating armature.

6. Cut two T-shaped commutator segments to fit the spool and attach as indicated in Fig. VI.121 g, bending them to hug the spool's curvature.

7. Wind the armature core tightly with wire in the direction indicated, giving approximately

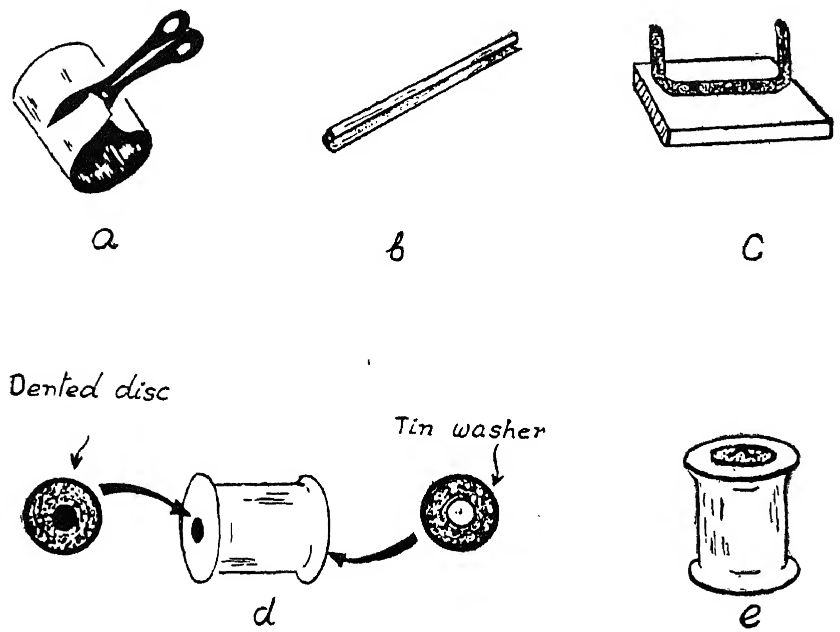


Fig. VI.121.
a. Cutting a large can.
b. Rolling a tin cylinder for the field magnet.
c. Core for field magnet mounted on wood base.
d. Tin washer and dented disc for armature spool.
e. Spool with dented disc attached.

3. Sharpen the 7 cm. nail and drive it up through the base.

4. Cut two pieces of tin can in the shape of circles about one cm. in diameter. Dent one outward at the centre as indicated, by hammering it with a blunt nail. Attach it to one end of the spool with small nails. This will serve as a low friction bearing and support the armature on the point of the nail. Make a hole in the centre of the other disc so that it will serve as a washer, and attach it to the other end of the spool.

5. Make a metal core for the armature by the same rolling and flattening method used in 2 above, using a rectangular piece of tin can 14-15 cm. long and 6-7 cm. wide. Attach this to the top of the spool over the dented disc. It will

100 turns on each end. Attach the ends of the wire to the commutator segments.

8. Wind the field magnet in the directions indicated, giving each end approximately 100 turns. Winding in this direction will result in exposing a north pole at on end and a south pole at the other end (Fig. VI.121 h).

9. Using a tin can cut two metal brushes in an L shape so that their large ends can be attached to the wood base and their small ends adjusted to brush against the commutator when the spool is in position on its nail pivot. The brushes should be in continuous contact with the commutator so that the current is flowing through the wires at all times except in the brief instants when

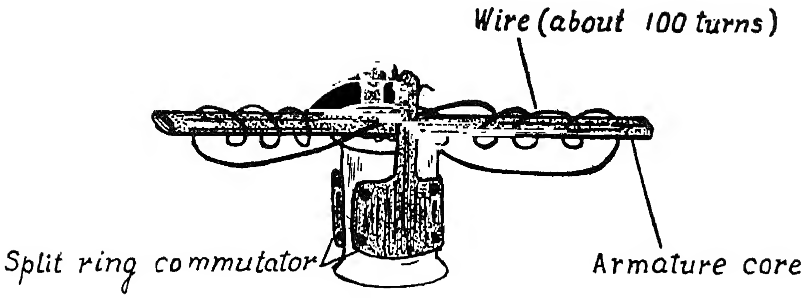


Fig. VI.121 f. Side view of armature.

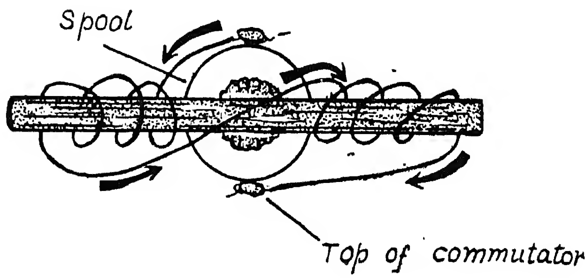


Fig. VI.121 g. Top view of armature showing direction in which it is wound.

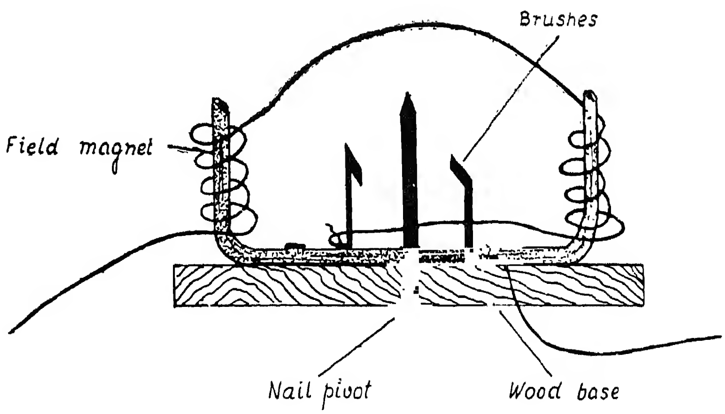


Fig. VI.121 h. Cut-away picture of base of motor.

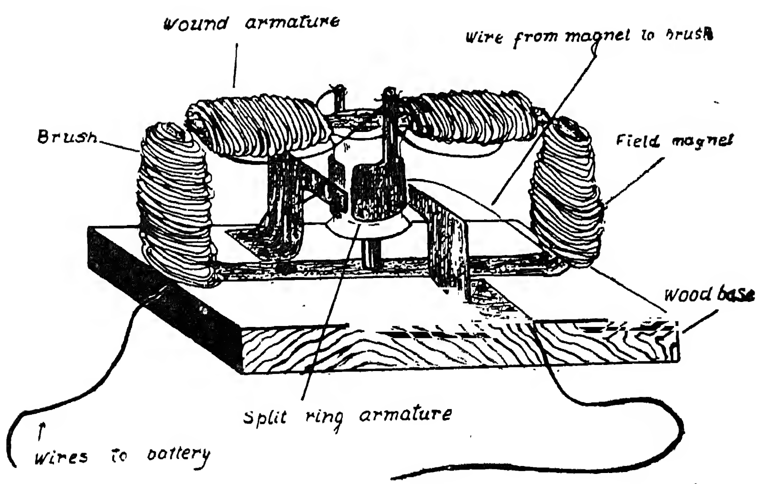


Fig. VI.121 i. Completed home-made motor.

commutator segments shift from one brush to the other.

10. Connect wire from one end of the field magnet to one brush.

11. Attach a wire to the other brush. (See Figures VI.121. h and i.)

12. Assemble the motor, placing the spool to pivot on the nail bearing. Connect a wire from the field magnet and another from the other brush to about four dry cells or to a storage battery. The motor should run.

Concept 5-c,d (p. 73) : (c) Motors vary in size from tiny ones used in toys to giant ones used in huge locomotives.
(d) Since motors can be made in all sizes, they are widely used to operate all kinds of household appliances, industrial installations where mechanical energy is required.

Bring some electric toys to class to show the uses of electric motors. Point out that the principle of reversing magnetic fields operates in all motors, big or small.

Find pictures of large electric motors. Plan a field trip to an industry or public utility plant where big motors are used.

Concept 5-e (p. 73, 74) : Some household appliances which use motors in various ways are :

1. Vacuum cleaner—turns a fan creating air current which collects dust instead of stirring dust around as a broom does.
2. Refrigerator—turns a compressor which pumps refrigerant from evaporator to a condenser—thus cooling the refrigerator and making possible the storage of perishable food.
3 Washing machine—motor drives agitator thereby forcing wash water through clothes. It also dries the clothes by means of a wringer or by spinning them.
4. Power pump—motor turns pump thereby lifting water.
5. Electric fan to turn blades.

List all the places you know where electric motors are used.

1. Demonstrate in class the working of a vacuum cleaner. Locate the electric motor.

2. Draw a diagram of how a refrigerator works. Perhaps some of you have electric refrigerators. Where is the electric motor? The electric motor runs the compressor. A refrigerant is a substance such as sulphur dioxide which changes from a gas to a liquid (condenses) when slightly compressed and cooled and later readily evaporates when the pressure is reduced. The refrigerant is circulated by a rotary pump or compressor which is run by an electric motor.

3. If an electric motor driven washing machine is available, have someone describe how the motor works to drive an agitator, which forces water through the clothes.

Some students may have seen a clothes drier which may dry the clothes by spinning them about.

4. Ask those who have seen a power lift pump to draw it and show how the electric motor is used.

5. Procure an old electric fan for a demonstration in your classroom. Perhaps the electric motor may be useful as a model, the parts of which can be labelled and studied.

Major Concept 6. The telephone enables one to talk with someone at a distance. The essential parts of a telephone are a transmitter and a receiver.

Concept 6-a (p. 74): The transmitter converts sound waves into a varying electric current. Changes in pressure on a box of carbon granules change the resistance in an electric current so that it corresponds to the waves.

1. To show how increased pressure on carbon makes it conduct electricity better, connect 2 carbon rods from old dry cells in series with a dry cell and an ammeter. (A battery tester ammeter will do—or one from an old automobile.) Touch the carbon rods lightly and note the amount of current flowing. Press them together tightly and note the current flowing. (An electric bell may be used in place of the ammeter. In this case the loudness of the bell serves as a measure of the current.)

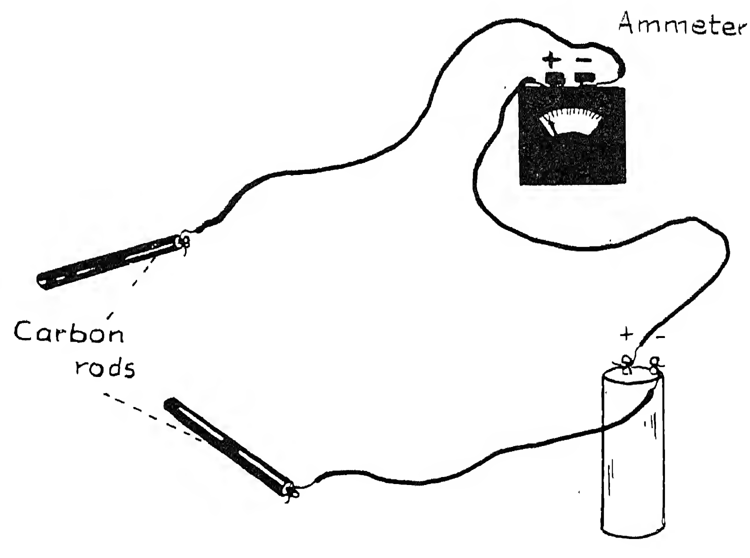


Fig. VI.122. Pressure on carbon rods affects amount of current flowing.

2. Obtain a small plastic pill box and punch a small hole in the bottom so that a wire soldered to a metal washer in the bottom of the box can pass through. Grind the carbon rod from an old dry cell to a coarse powder and fill the box to about a quarter-inch with this powder. Place another metal washer to which a wire is soldered on the top of the carbon granules and connect the wires to a dry cell and a 1.5 volt torch lamp in series as shown in figure Fig. VI.123. Press down on the top washer with an eraser and note the brightness of the lamp. Release the pressure and note the change in brightness.

Explain the reason for the difference.

3. Obtain a wooden cigar box and two double edged razor blades. Force both razor blades into the top of the cigar box so that they stay upright (Fig. VI.124). The blades should be about $1\frac{1}{2}''$ apart and placed along the grains of the wood so that they will stay more securely in position.

Remove the insulation from the ends of two

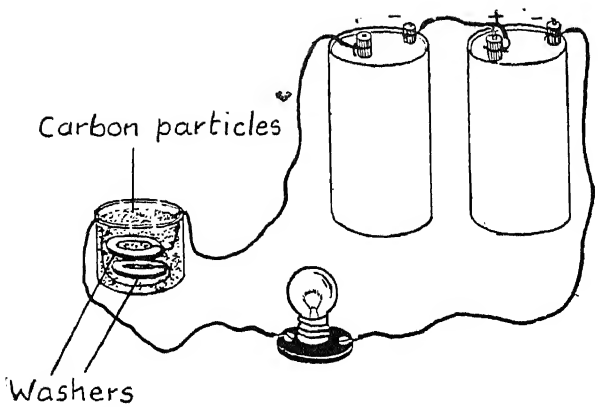


Fig. VII-123. Pressure of carbon particles affects flow of electricity.

pieces of bell wire. Wrap one end of each wire securely around a hole of the razor blade. Insert two small screws partially into the cigar box and wrap each wire around a screw.

Now split a pencil lengthwise. Remove the carbon. Place two pieces of carbon (pencil lead) across the sharp edges of the razor blades.

Obtain a receiver or a headphone from a radio repair shop. Connect the wires from the blades in the cigar box to the telephone receiver and also to a source of current as shown in the figure. The cigar box telephone is now ready for use. When the carbons are pressed gently a loud sound is produced. Place an alarm clock near the mouthpiece and adjust the position of the carbons and you will get a loud sound.

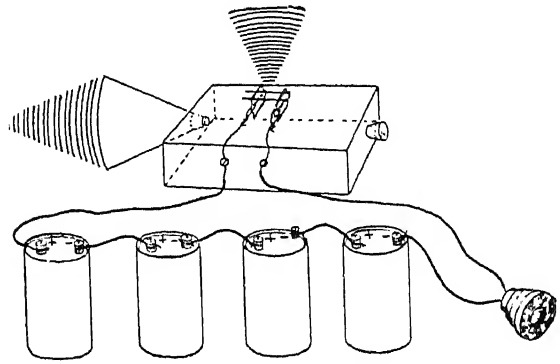


Fig. VI.124 A cigar box telephone.

Set up a two-way telephone system. Use two cigar box telephones and two receivers, or two telephone transmitters and receivers if such are available. The students will enjoy using this system both in the same room and in two different rooms.

Concept 6-b (p. 74): The receiver converts varying electric current back into sound wave by the action of an electromagnet on a steel diaphragm.

Obtain a dry cell, telephone receiver, iron file, and bell wire. Attach one length of wire to the receiver and to the dry cell. Attach a second length of wire from the receiver to the handle of the file. Attach a third piece of wire to the other pole of the dry cell and leave the other end free. Now scrape the free end of the wire along the file and note the effect when you listen in the receiver.

As the amount of the current varies, the receiver's electromagnet changes, thus causing the receiver disc to vibrate. This produces sound waves. (Refer to Fig. VI-53.)

Concept 6-c (p. 74): An amplifier is used to make transmission possible over a greater distance.

When electric signals travel long distances they become weaker. These weak signals are strengthened by placing amplifiers in the circuits. Trans-continental telephone messages are amplified several times in this way.

Major Concept 7. The gramophone reproduces music by converting the wave placed on a thin disc into music. It consists of four electric parts.

Concept 7-a,b,c,d (p. 74) :
(a) An electric motor or a mechanical device turns a turn-table at a constant speed.
(b) A pile-up with a small microphone in it converts the mechanical motion of the needle into a varying electric current.
(c) The varying electric current is amplified as in a radio.
(d) The varying amplified current is passed into a loud speaker, where an electromagnet operating in a magnetic field moves a diphragm, producing sound waves.

If a gramophone is available, bring it to the classroom and show how it works. While a record is turning, hold the corner of a 3 x 5 card in the grooves of a record and see how the grooves make the card move back and forth producing sound. The grooves of the record move the needle back and forth.

Look at the pick-up arm and see the device that converts the mechanical vibrations of the needle into a varying electric current.

Open up the gramophone box and see the motor which drives the turn-table, the amplifier and the loud speaker. Discuss how each works.

Major Concept 8. A tape recorder records and plays back the voice or music on a magnetic tape.

Concept 8-a,b (p. 74)
(a) An electromagnet changes the magnetic pattern on a tape to correspond to a varying current produced in a microphone.
(b) By moving the tape through a receiving head (coil), a current is generated in the coil which corresponds to the pattern on the tape. This current is then amplified and sent through a loud speaker as in the gramophone.

If a tape recorder is available, bring one to the classroom and study how it works. You may need to take off the outer cover to see the working mechanism.

Observe the motor which turns the reels of tape. Note the various switches which are used in controlling the currents when recording, and when using it to play the magnetic record on the tape.

Note the position of the tape when recording. When the switch is set for recording, bring a compass needle near the recording head and note the attraction of the magnet.

Note the position of the tape when it plays back the magnetic pattern on the tape.

Note the loud speaker and the radio amplifier.

Major Concept 9. A radio transmits energy via electro-magnetic waves making possible the sending of messages without wires.

Concept 9-a (p. 75): A sending station produces an oscillating current of a particular high frequency between the earth and the antenna.

To show that an electromagnetic radio wave is produced by an oscillating current, connect a spark coil to three or four dry cells in series and note the effect on a nearby radio when there is an electrical discharge.

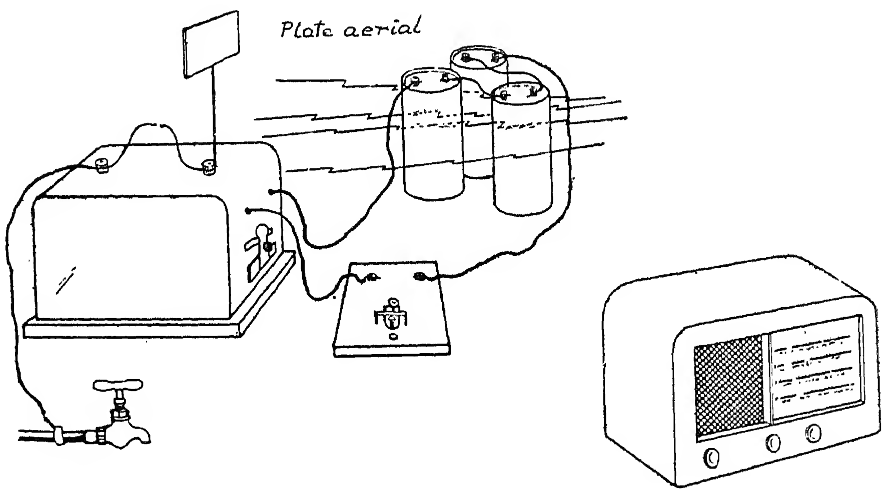


Fig. VI. 125. Electromagnetic waves are produced by an oscillating current.

The effect can be increased by connecting one side of the spark gap with a water pipe, and by attaching a small metal plate or short antenna to the other. Note that every time a spark oscillates back and forth across the spark gap, a noise—*static*—is heard in the radio. (If an induction coil is not available—get an ignition coil from an old automobile or a magneto from an old engine. Either may be used to generate an oscillating spark.) Note that this disturbance is picked up by the radio no matter where the tuning dial is set. This is because the spark has varying frequencies. The carrier wave produced in the transmitter of an AM (Amplitude Modulation) has a definite frequency, and so is picked up by the radio receiver at a particular place. Radio tubes are used to produce the oscillations; while the frequency of the oscillations is regulated by quartz crystals in broadcasting stations.

Concept 9-a (p. 75): (i) This oscillating current generates en electromagnetic wave around the antenna which wave spreads out in all directions. This wave is known as a carrier wave. Its frequency is from 550 kilocycles to 15,000 kilocycles. (Radio frequency).

Electric power is transmitted by an electric current which alternates 100 times each second—makes 50 cycles each second. Around each wire carrying such current there is generated an electromagnetic wave of 50 cycles. To demonstrate that this electromagnetic wave can carry energy through

the air just as the higher frequency radio waves do, connect a coil of several turns of wire with a heating element and a source of 220 volts A. C. Connect another coil of wire to a pair of earphones as shown in the diagram. direction of the sending coil can thus be determined. This is also easily demonstrated by rotating a radio receiver until the reception from a particular station in the receiving set

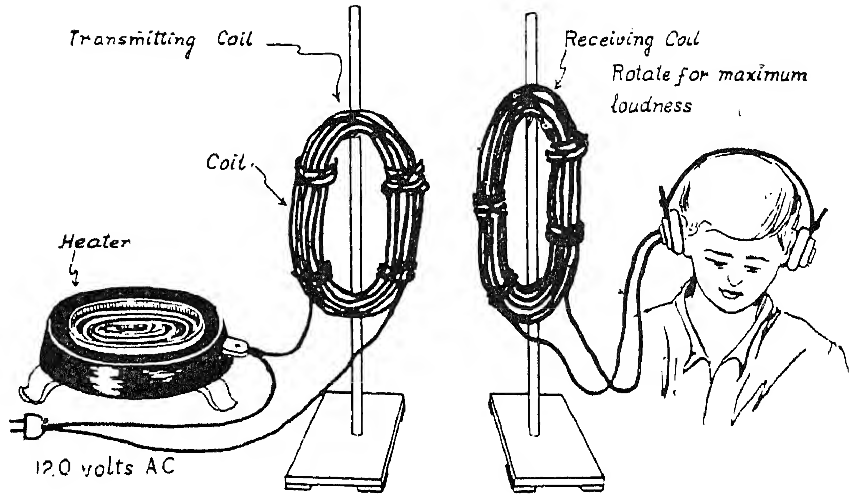


Fig. VI.126. Electromagnetic (heat) waves carry energy like radio waves.

Rotate the receiving coil in the vicinity of the sending coil until the loudest hum is heard. The serves as a direction finder for the sending station.

Concept 9-a, b, c (p. 75) : (ii) This oscillating current is modulated by means of a transformer which carries audio frequency waves generated by a microphone. The amplitude of the carrier waves varies as the sound waves picked up by the microphone.

(b) The electro-magnetic radio wave sets up an oscillating current in the radio antenna—between the antenna and the ground (the chassis of the receiving set). This varying signal is passed through a coil (a transformer without an iron core) where its variations are sent to the grid of a radio tube.

(c) The varying voltage on the grid of a radio tube is used to vary the electrons escaping from the filament to the plate of the tube. In this way the magnitude of the variations is magnified thousands of times. This magnified current may be sent into the grid of other radio tubes—again stepping up the magnitude of the variations.

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1. It is difficult to demonstrate the modulation of a radio frequency current in a transmitting or sending circuit. The same modulation effect can be readily demonstrated in a simple one-tube radio or crystal receiver. To do this, construct a one tube radio set, as shown in Fig. VI. 127. a.; then connect an audio frequency transformer and modulation circuit in the receiving circuit as shown in the figure. Many, if not all of the parts may be procured from a radio repair shop. (This set must be operated near a broadcasting station.)

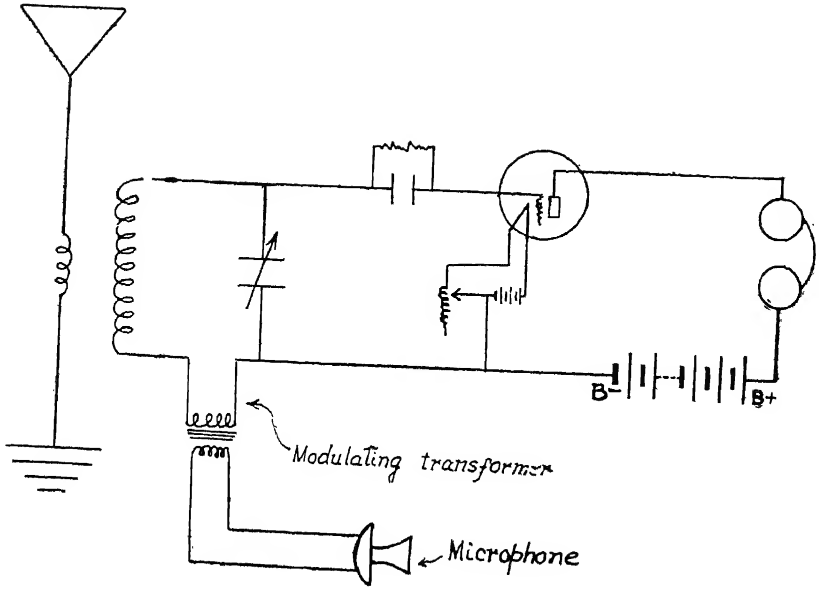

Fig. VI.127 a. One tube ditector circuit with a modulating circuit attached.

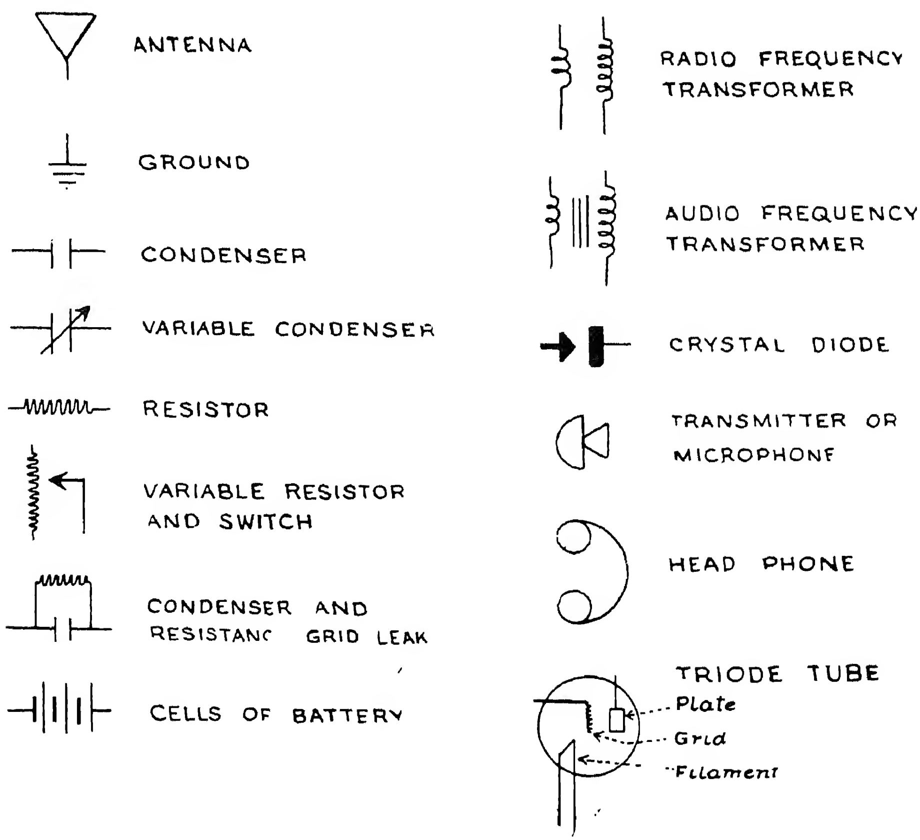

Fig. VI.127 b. Conventional radio symbols

In the place of the one-tube radio circuit a transistor radio circuit may be used. The transistor will operate on a few torchlight cells and does not require expensive batteries.

The modulating audio frequency transformer can be connected with the circuit.

When the receiving set and the modulating set switches are turned on—one can speak into the transmitter and his voice will be heard in the headphones. The audio frequency transformer modulates the current flowing in the radio circuit. The varying current in the audio frequency transformer generates a varying magnetic field in the transformer. This moving magnetic field modulates the current flowing in the secondary of the transformer and, since this is a part of the radio circuit, modulates the current flowing in the radio circuit.

2. Build a simple crystal radio set like that shown in Fig. VI. 128.

The radio wave from the sending station generates an oscillating electric current in the antenna, antenna coil and ground circuit. The oscillating current in the antenna coil sets up an oscillating current in the secondary of the antenna coil. The variable condenser makes the receiver circuit resonate with different frequencies. It is used to tune in different broadcasting stations. The germanium crystal rectifies the current so that only direct current flows through the earphones. The earphones respond only to the audio frequency variations in amplitude and convert the varying electric current into sound.

3. To show how a varying voltage on a radio tube grid acts as a valve, connect a radio tube in a circuit as shown in Fig. VI. 129.

4. To see how the temperature of the filament in the tube affects the quantity of current flowing in the plate circuit (through the milliammeter), vary the current flowing in the filament by turn-

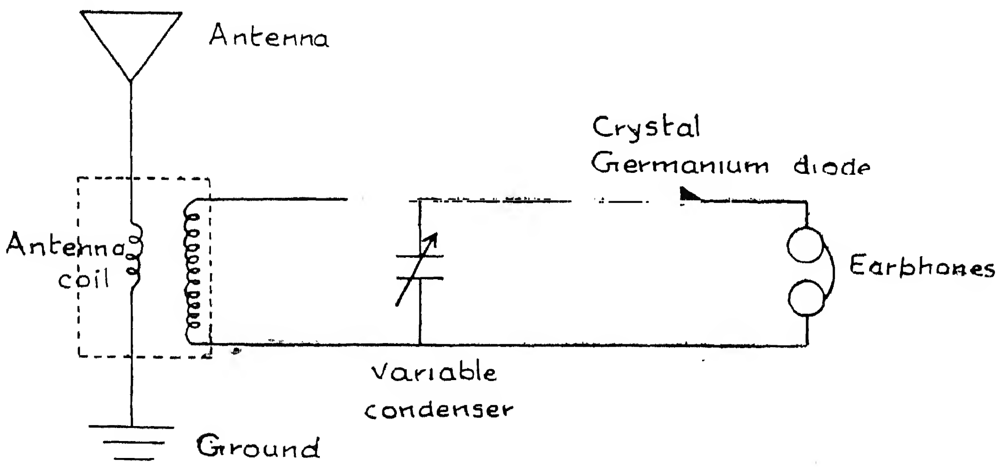

Fig. VI.128. Home-made crystal set.

A germanium diode can be procured from a radio shop. A variable condenser and a radio frequency coil may be procured from an old radio or from a radio repair shop. Or a radio frequency coil may be made by wrapping insulated wire on a paper cylinder such as a mailing tube. Wrap approximately 8 or 9 turns of wire on the antenna coil and 80 or 90 turns on the circuit coil. An antenna about 30 meters long should be connected to the ground through the antenna coil.

By experimenting with the above circuit you should be able to tune in a local broadcasting station.

ing the rheostat at R. When the filament is hot, current flows from the negative of the B battery to the filament, across the gap in the vacuum tube to the plate, to the milliammeter and back to the B battery. This emission of electrons from a hot filament was first discovered by Edison and so is known as the Edison effect. It was this effect that De Forest used in developing a triode vacuum tube which could be used to amplify weak signals. Does any current flow in the plate circuit when the filament is cold? How does increasing the temperature of the filament by increasing the A current flowing in the filament circuit, affect the

quantity of current flowing in the plate circuit? (See Figure VI.129.)

5. To see how the positive charge on the plate of the triode vacuum tube affects the flow of current in the plate circuit (through the milliammeter), change the connections on the B batteries to vary the voltage across the gap from the filament to the plate. Does an increase in the plate voltage also cause an increase in the current flowing in the plate circuit? Account for your results. Recall the effect of positive electrostatic charges on negative electrostatic charges. (See Figure VI.129.)

6. How would you expect a charge on a grid placed between the filament and the plate to affect the flow of electrons from the filament to the plate? De Forest reasoned that a small variation on a grid charge might make a big difference in the current flowing in the plate circuit, and that in this way weak signals flowing in the radio antenna circuit could be greatly amplified. You can show the effect he discovered by changing the voltage on the grid circuit with a 3-volt battery placed in the grid circuit. The grid circuit is normally connected to the output of a transformer, such as radio frequency transformer in the antenna circuit known as the antenna coil.

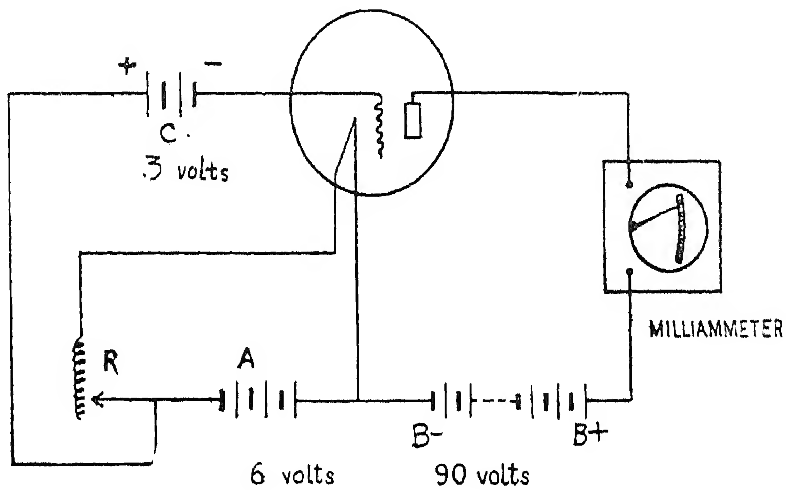

Fig. VI.129. A varying voltage on a radio tube grid acts as a valve.

Take readings of milliamperes of current flowing when the negative terminal of a 3-volt battery is connected to the grid at C. Then reverse the terminals on the 3-volt battery at C. Note the effect on the quantity of current flowing through the tube. Disconnect the 3-volt battery at C and note the milliamperes of current flowing in the circuit. The grid acts as a valve. When it is negative, it stops the flow of electrons from the filament to the plate. When it is positive, it increases the flow of electrons from the filament to the plate.

Find out more about transistors; read about the history of television.

UNIT VII Matter and Materials

CLASS VI

Major Concept 1. Elements are substances whose molecules are made up of the same kind of atoms. Materials can be separated into their elements.

Concept 1-a (p. 78) : There are about 92 natural elements.

1. To explain that all matter is composed of different kinds of *elements,* set pupils on an exploration to find what the earth is made of. Let them list such things as land, water, air, wood, rocks, soil, plants, animals, etc. Then guide the discussion with other queries like:

"What is water made of" ?

"What is wood made of" ?

This will lead to the idea that these substances can still be resolved into simpler substances like hydrogen, oxygen, nitrogen, carbon, etc. Also they will learn that scientists may combine these into complex things, as when carbon burns in air to give carbon dioxide, or iron rusts into iron oxide (idea of analysis and synthesis).

Tell them how ancient peoples thought that all matter was composed of earth, air, water and fire, but now we have found that there are more than 100 simple kinds of substances called elements which go to make up the various forms of matter. In an element all the particles are alike in properties.

2. Assign a committee of children to make a list of elements from some chemistry book or chart and let them find with which of these they have any familiarity.

3. Set up committees of pupils to go on an 'element hunt' to find and bring to the class as many elements as they can find. Ask each committee to prepare a report stating where the elements came from and giving other information about them, such as their uses in daily life, industry, etc. The list can be compiled alphabetically somewhat like the following:

Element	*Where found*
aluminium	pots and pans, foils
argon	electric bulb
carbon	wood, candle, fuels
chlorine	bleaching powder
chromium	chromium plated cycle parts
copper	coins, wire, pots
gold	jewellery
hydrogen	water
iodine	tincture of iodine
iron	nails, paper clips, pipes, rail, tools
lead	type metal
nickel	coins
nitrogen	air
oxygen	air, water
phosphorus	matches
silver	jewellery, coins
sulphur	disinfectants
tin	tinned pots, foils
zinc	torchlight cells, galvanized iron sheets and vessels.

4. The periodic chart can be shown to indicate that in all about 92 common elements are found. Besides these there are some elements

which have been artificially prepared by chemists so that in all over 100 elements are really known. It should be said that chemists have a short symbol or name for each element.

Concept 1-b (p. 78) : Man has made some other elements and there are now over 100 known elements.

1. To recall that when water evaporates it gets into air, let children list from their experiences as many examples as they can think of where water vanishes due to evaporation, like drying of clothes, ponds, tanks, perspiration, fruits and vegetables, ink while writing and so on.

2. It may also be recalled that evaporation is faster in summer than in winter; in dry seasons than in rainy seasons.

3. To show that water vapour has escaped into the air and remains there, condense some of it by keeping some crushed ice in a metal glass whose outer surface is quite dry. Why does the outside of the glass get moist after some time? Can the water pass through the walls ol the metal vessel? Where could it come from?

Major Concept 2. A compound is a substance whose molecules consist of two or more kinds of atoms.

Concept 2-a (p. 78) : The molecules of a compound are all alike.

1. To emphasize that a *compound* contains two or more elements, set up committees to go on a 'compound hunt' to find and bring to the class labelled samples of as many common materials as they can. Supply them with a chemistry text-book or chart containing common chemical substances and their formulae.

Let the children obtain the formula of each compound from the reference and write it on the label. If the formula contains the symbol of only one element, the material is an element . If on the other hand, the formula contains symbols of two or more elements, it is a compound as indicated in Table VII—1.

The smallest particle of a compound is called a *molecule*. All the molecules of a compound are alike and have similar properties.

The formulae also show that in a molecule of a compound the number of atoms of constituent elements is fixed, and therefore the atoms are in a proportion.

At this stage it is not necessary for the pupil to understand the full significance of the formulae or to memorize them, but it is important for him to have the thrill of discovering the elements in some of the most familiar materials and for him to be introduced to the 'shorthand' of chemistry.

2. Show pictures or models of a few simple molecules of familiar compounds to explain that atoms are held together by some kind of forces. If these forces are broken somehow, the compound can be analysed into its constituent elements.

TABLE VII—1. SUBSTANCES AND THEIR FORMULAE

Substance	*Formula*	*Nature*		
common salt	$NaCl$	Compound of	2	elements
washing soda	Na_2CO_3	,,	3	,,
moth balls	$C_{10} H_8$	,,	2	,,
sugar	$C_{12} H_{22} O_{11}$	,,	3	,,
vinegar	$CH_3 COOH$	,,	3	,,
milk of magnesia	$Mg(OH)_2$	,,	3	,,
baking soda	$NaHCO_3$	,,	4	,,
water	H_2O	,,	2	,,
lime	CaO	,,	2	,,
marble	$CaCO_3$	,,	3	,,

Concept 2-b (p. 78) : The constituents of a compound cannot be separated by mechanical means.

1. Show that water can be changed to ice by cooling or to steam by boiling, but it still remains water and retains its properties.

2. Send a direct current (from 2-3 electric cells) through water in which a few drops of acid have been added to make it a conductor. Watch for bubbles of hydrogen and oxygen at the negative and positive electrodes respectively.

3. Take a small pellet of sodium metal, dry it in folds of blotting paper and put it inside a small wire cage (made from a piece of wire gauze). Put this wire cage in a trough of water and see bubbles of hydrogen rising. Collect some gas in a test tube full of water held inverted over the cage.

Discuss why this gas hydrogen could not come from sodium. What is its probable source?

Concept 2-c, d (p. 78) : (c) The properties of a compound are different from those of its constituents.
(d) The constituents of a compound are always in a definite proportion.

1. Refer to the properties of hydrogen and oxygen obtained by electrolysis of water compared with the properties of water itself. (Fig. VII. 7.)

2. Burn a few inches of magnesium ribbon and examine the ash formed.

3. Dissolve some copper filings in a little dilute nitric acid and examine the blue solution of copper nitrate. Evaporate the solution carefully on a watch glass. Compare the properties of the blue crystals with copper and nitric acid.

4. Suspend an iron nail for 10 minutes in a solution of blue vitriol (copper sulphate) and compare the deposit of copper with the blue salt.

5. Burn a match and note that the remaining carbon from the wood is quite different from the carbon present in the cellulose of the wood.

6. For development of concept 2-d see concept 3-c item 2.

Major Concept 3. A mixture is a substance whose molecules are of different kinds.

Concept 3-a (p. 78) : The components of a mixture can be separated by physical means.

1. To show that a *mixture* consists of two or more elements or compounds which are not chemically united and therefore are separable by mechanical means, do the following:

a. Mix iron filings with sulphur. Now use a magnet to attract the iron filings. Can you separate the two constituents in this way?

b. Take a little of the above mixture in a test tube, add some carbon disulphide and shake well. What happens to the sulphur and iron respectively? Pour out the liquid on a watch glass. What is left behind? Evaporate the carbon disulphide and examine the residue.

c. Mix some sand, salt, sawdust, iron filings and a few naye paise. Discuss how these may be separated. Try this procedure: Separate the naye paise from the rest by using a simple wire sieve. Pull out all the iron with a magnet. Then put the rest in a beaker of water. Sawdust floats and can be ladled out with a spoon and dried on a blotting paper. The sand falls to the bottom. The salt dissolves. Pour the water in a small basin and evaporate it so that the salt remains. The sand left at the bottom may be dried between folds of blotting paper.

Concept 3-b (p. 78) : The properties of a mixture are an average of those of its components.

To show that the properties of a mixture are an average or intermediate of those of its constituents, do the following:

1. Mix some common salt and sugar in a clean vessel. Take a pinch of it and taste. Is it salty or sweet or both?

2. Mix some sand and a coloured salt like copper sulphate powder on a tray. What is the nature of its physical appearance and colour?

Put a little of the mixture in a beaker half full of water. Do both components go into solution? What is the colour of the solution? Where is the sand now?

Concept 3-c,d (p. 78) : (c) The components of a mixture may be in any proportion.
(d) The constituents of a compound are always in a definite proportion.

1. To show that components of a mixture may be in any proportion, mix varying proportions of sugar and sand or sulphur and iron powder or oil and water. Shake the mixture and separate the constituents.

2. To show that when a compound is formed, the constituents are always needed in a definite proportion, take 1-2 ml. of dilute sulphuric acid in a beaker and add a gramme of granulated zinc to it. See what is left behind after the effervescence stops. Then take another test tube with about 6 ml. of similarly diluted acid and add only one piece of granulated zinc. Test the presence of acid in both cases with litmus paper. (See concept 2-d.)

What is left unchanged (acid or zinc) in the two cases? Why is either zinc or acid left unchanged in either case?

Major Concept 4. Matter undergoes changes. These changes may be physical or chemical.

Concept 4-a (p. 78) : When a physical change takes place, no new substances are formed.

To show that in a physical change no new substances are formed, do the following experiments:

1. Dissolve a pinch of salt in water in a test tube. The original salt has changed from its solid form. Taste a drop of the water to see that the characteristic saline taste of salt still exists. Evaporate a little of the solution on a spoon and examine the residue left. Is it different from the original salt?

2. Boil some water in a small kettle. As steam is formed, water goes on disappearing. What form is it changing into? Hold a metal glass containing cold water (or preferably ice) near the spout of the kettle and observe droplets of water collecting on the sides of the glass. Test to find out if it is really water.

(A good test for water is to pour a drop on white anhydrous copper sulphate, which will instantly turn blue.)

3. Take a little paraffin wax in a spoon and warm it so that it melts to a clear liquid. In what way has it changed? Drop the liquid in a vessel of cold water and examine the substance.

In the above cases the changes undergone by salt, water and wax have not produced any new substance. Such changes are *physical changes*.

Concept 4-b (p. 78): When a chemical change takes place, new substances are formed.

1. Hold a piece of charcoal and ignite it over a stove and let it continue to burn completely. Examine the residue (ash). Is it similar to the original charcoal? What has happened to it?

2. Repeat the above experiment using a piece of magnesium ribbon.

3. In a beaker containing dilute sulphuric acid put a few pieces of zinc shavings or granules and observe what changes take place. Collect the rising bubbles of gas by inverting a test tube full of water over the zinc. When the test tube is full of gas, close it with the thumb, then bring the mouth of the test tube close to the flame and open it. What happens? Is the gas in any way similar to zinc or the acid or water?

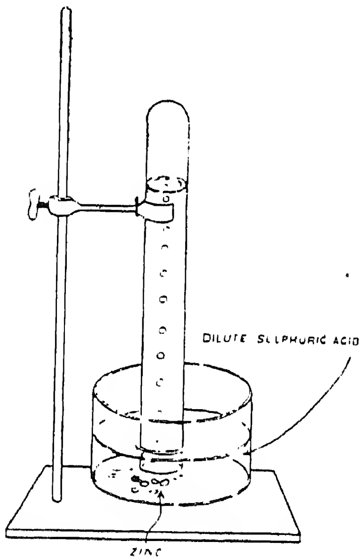

Fig. VII.1. Hydrogen is evolved when zinc reacts with sulphuric acid.

When all the zinc is dissolved or the action ceases, take a little of the clear solution in a porcelain dish and evaporate to dryness. What is left behind? Is it in any way similar to zinc or acid or water?

4. Take a wide test tube about one third full of water. Add to it a pinch of either washing soda or baking soda. Is there any kind of action? Now add a few drops of hydrochloric acid. See what change takes place. Hold a glass tube containing a drop of lime water over the mouth of the test tube. Does the drop turn milky?

(It is presumed that pupils have seen or done this test for carbon dioxide gas using lime water.)

When all action ceases, take a clear portion of the solution from the test tube in an evaporating basin and evaporate it to dryness. See what residue is left. Taste a fragment of the residue and compare it with any known substance.

In all the above cases the original substances have undergone complete change to produce altogether new substances. Such changes are *chemical changes*.

Materials In Daily Use

Major Concept 1. Soap and detergents are used for cleaning purposes.

Concept 1-a (p. 78): Soap is formed by the action of caustic soda or caustic potash on a vegetable oil or fat.

The formation of soap from an alkali, such as caustic soda, and vegetable oil like til, groundnut, mahua etc., may be demonstrated. Add one part alkali to four parts of cold water in an iron or enamelled vessel, and stir it well. When the caustic soda is dissolved, warm vegetable oil, add it to the alkaline solution and stir thoroughly until the mixture becomes thick like jaggery. Pour the mixture into a cardboard box lined with wax paper. When it has set hard enough, allow it to dry in sunshine for some days. Vary the proportions to improve the soap.

Show that the soap so made forms lather when rubbed with water.

Concept 1-b (p. 78): Soap forms many bubbles which attract dirt particles.

1. Dissolve some soap in water and stir it thoroughly. You see bubbles of various sizes made of thin soap film.

2. To show that soap bubbles attract dust particles wash the soiled hands of a pupil with plain water and of another pupil with soap and water so as to raise bubbles of soap. Let the washing in both cases be collected in clean vessels. Which of the wash waters is dirtier?

Concept 1-c (p. 78): The soap breaks up the oily layer physically and dissolves the greasy matter.

To show that soap breaks up and dissolves the oily layer to which dirt keeps sticking, take two pieces of dirty rag. Place one in a beaker containing tap water and place the other in another beaker containing soap water. After a few minutes wash each under the tap separately. Which becomes cleaner?

Concept 1-d (p. 78): Toilet soaps are less caustic than washing soaps.

To show that toilet soaps are less caustic than washing soap, make a dilute solution of phenolphthalein in spirit. Dissolve a few chips of toilet and washing soap in water separately in two vessels. Pour one drop of phenolphthalein in each. See which shows a deeper pink colour.

Demonstrate the change of colour of phenolphthalein by pouring a drop on a dilute solution of caustic things like caustic soda, lime or washing soda. A chemist will have phenolphthalein.

Concept 1-e (p. 78): Modern detergents do not contain soap but serve the same purpose.

To show that soaps and *detergents* have the same cleansing function of speeding the wetting process, take three tumblers each half full of water. To one add a pinch of detergent powder, to the second add some soap powder and keep the third as it is. In each glass put a few pieces of white cotton strings. Observe the order in which the strings sink to the bottom in the three glasses.

What does it indicate regarding the speed with which the surface of the strings get wetted?

Major Concept 2. Matches are used to make fires easily.

Concept 2-a (p. 79): Different substances catch fire at different temperatures known as ignition point or kindling temperature.

1. To show that different substances have different *kindling temperatures*, take a piece of paper, a stick of bamboo, a stick of hard wood, a piece of coal and put each of them on a wire gauze over a small fire. See in what order they catch fire. Try other materials.

2. Put a few drops of spirit or petrol and a few drops of kerosene oil in two separate dishes and apply the flame of a match stick to both. Which of them catches fire faster?

3. Light a candle. Observe that it takes some time for the wick of a candle to start burning when a burning match stick is applied to it.

Concept 2-b (p. 79): Red phosphorus has such a low kindling point that it glows by the heat of friction.

1. To show the low kindling temperature of red phosphorus, darken the room and slowly rub small piece of red phosphorus held with a pair of a tongs on a piece of stone. Let the pupils observe the glow of phosphorus.

2. Rub the coated surface of a match box with a piece of sandpaper in a dark room to show the glowing of the surface caused by heat of friction.

Concept 2-c,d,e (p. 79): (c) The temperature at which red phosphorus glows is sufficient for antimony sulphide to catch fire.

(d) The burning of antimony sulphide produces a temperature at which paraffin and the soft wood of the match stick catch fire.

(e) In safety matches, the side of the match box is coated with a mixture of red phosphorus (a low kindling material), fine sand (for friction), and glue (for holding it). The match stick is made of soft wood soaked in molten wax (to make it more inflammable), and the tip of the stick is coated with antimony sulphide, powdered glass and glue.

1. To show pupils the functioning of a safety match, dissolve a pellet of red phosphorus in carbon disulphide and add some fine sand and a little powdered gum to make it into a paste. Apply it carefully on a wooden surface and allow to dry.

Then take a few fine softwood sticks (stripped bamboo will do), each piece about 10-15 cm. long. Dip them first in a little molten paraffin wax and then on the tip apply a little paste made of antimony sulphide, powdered glass, glue and a little water. Allow the heads to dry.

Then use them like ordinary match sticks by rubbing the heads on the prepared surface.

2. The sequence of burning of the match stick can be shown in the following manner.

glowing of phosporus warms the surface ⟶ starts the burning of antimony sulphide ⟶ starts the burning of the stick coated with paraffin.

AIR

Major Concept 1. At the surface of the earth the air consists of about one-fifth oxygen and four-fifths nitrogen. It also contains varying amounts of water vapour and dust.

Concept 1-a, b (**p. 79**): (a) Oxygen is removed from the air when metals rust, fuels burn or respiration occurs.

(i) Oxygen may be completely removed from a jar of air by the rusting of iron or by the burning of red phosphorus.

(ii) A burning candle stops burning when about one-fourth of the air is removed from a jar of air.

(b) When oxygen is removed from the air, the remaining gases are mostly nitrogen.

(i) Nitrogen is called an inert gas because it does not support combustion.

(ii) Nitrogen does not easily combine with other elements.

(iii) But for the variation in water content, the composition of the air remains quite constant.

To show that oxygen is removed when metals rust, fuels burn or living things respire, some of the following experiments may be done.

1. Moisten the walls of a gas jar and sprinkle some iron filings so that they stick to the walls. Invert it over a trough containing some water. Observe the level inside the jar. Leave it for a week and observe the rise of water level. Find out what part of the air has been consumed in this change.

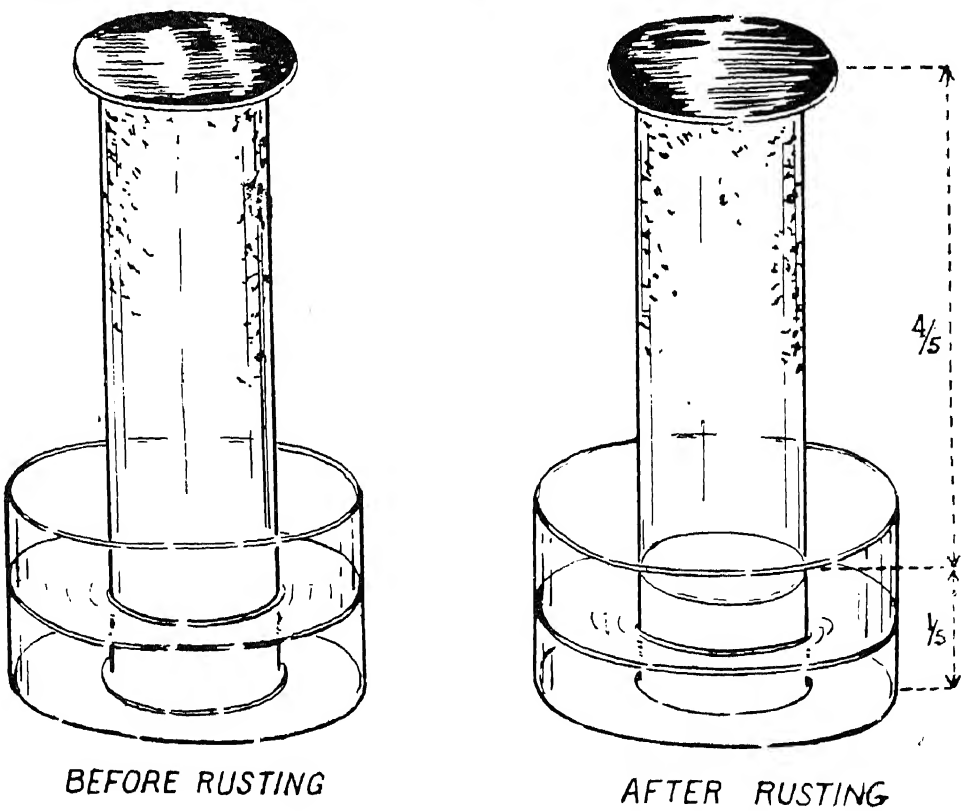

Fig. VII. 2. Oxygen is used up in rusting.

To know that oxygen has been used up, cover the open end of the jar with a glass plate as you remove it from the water. Uncover slighlty to insert a burning splinter of wood carefully into it. Why is it extinguished ?

2. Place a piece of red phosphorus about the size of a pea in a crucible. Float it on a trough containing some water. Keep a bell jar over the trough, covering the crucible. Measure the height of the bell jar above the level of water. Heat a long iron wire red hot over a spirit lamp flame and touch the piece of phosphorus so that it is ignited. Quickly close the lid of the bell jar.

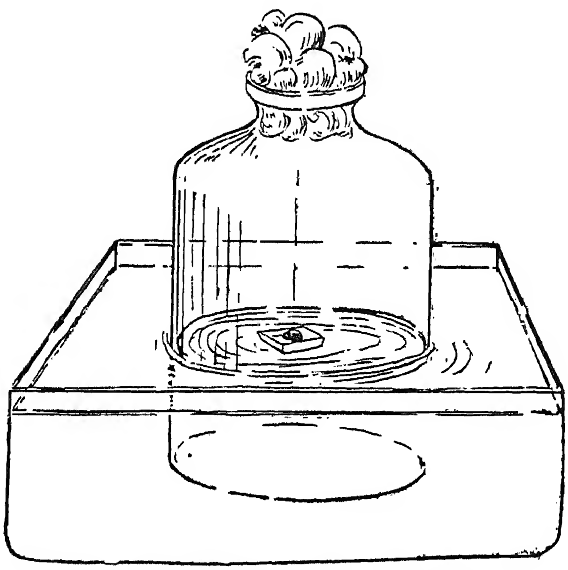

Fig. VII. 3. Oxygen is used in burning.

Observe how long the phosphorus burns and the effect on the water level inside the bell jar. Measure the water level and find out how much of the total air has been used up.

As in the previous experiment test the residual air with a burning splinter.

From these it may be inferred that about 1/5th of air is active in supporting combustion (burning or rusting). It is oxygen. The remaining 4/5, mostly nitrogen, does not support burning.

3. Fix a candle on a glass trough. Pour some water on the trough and light the candle. Place a bell jar carefully over the candle, mark the level of water inside and outside the jar and quickly close the open end with a tight cork.

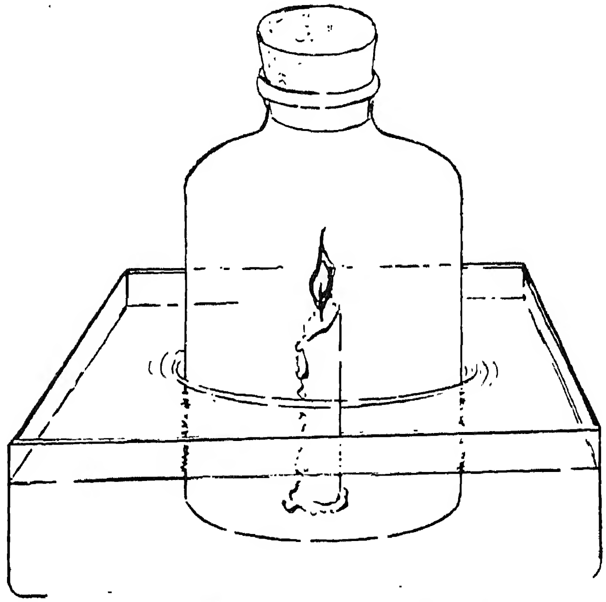

Fig. VII. 4. Oxygen is used in combustion.

The water in the bell jar will rise as the candle burns out. It appears that measuring the water level inside the jar will tell what proportion of air is oxygen. Why is this true ? The candle heat expands the air, forcing some of it out before the bottle can be corked. Therefore the measurements cannot be accurate.

Concept 1-c. (p. 80) : The water vapour content of the air varies.

(i) It depends upon geographic factors (whether over land or sea).

(ii) It depends upon the temperature. The warmer the air the greater its water holding capacity. When cold moist air is heated, it becomes hot dry air.

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1. To show that water vapour content of the air varies, recall :

(*a*) experiences of your skin feeling dry in winters and extreme summers; and

(*b*) the difference in time taken to dry clothes in rainy season and dry season, or even at noon and at night.

2. To show geographical factors, use a large wind map of the world and discuss how the direction of wind would indicate the relative amount of vapour at a certain place. Discuss the Indian monsoons.

3. To show that colder air has less water-holding capacity, take a metal vessel with crushed ice in it. Cover it and observe how water droplets from the vapour in air condense on its outer surface.

4. A cloud in a bottle could be made to explain the phenomenon of condensation and evaporation. Place about 2.5 cm of warm water in a large glass bottle and sprinkle a little chalk dust into the air inside. Plug the bottle with a tight-fitting one-holed rubber stopper through which passes a 10 cm long glass tube. Connect the glass tube to a bicycle pump with a piece of rubber tubing. Hold the stopper and have a student pump air in. When the air has been compressed inside the bottle, let the stopper blow out and observe what happens inside. Explain why the cloud appears and disappears.

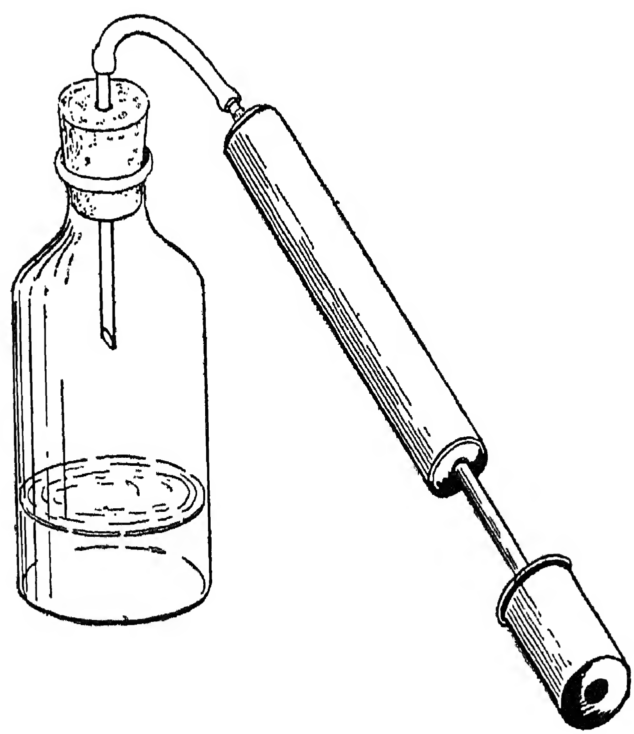


Fig. VII. 5. Cloud demonstration.

OXYGEN

Major Concept 1. Oxygen is widespread at the surface of the earth.

Concept 1-a (p. 80): Oxygen gas from air dissolves in water.

1. Fill a glass with water and observe it closely. Let the glass stand in a warm place for some hours. Observe what happens.

2. To show that the dissolved gas in water is only air, (oxygen and nitrogen), take a wide tall beaker three-fourths filled with water. Take a funnel with its diameter slightly smaller than the beaker and the length of its stem shorter than the height of water in the beaker. Place the funnel upside down in the beaker and invert a test tube filled with water over the stem of the funnel. Warm the beaker over a wire-gauze and collect as much dissolved air as you can without boiling the water.

Test the collected gas by a burning splinter to see if it continues to burn.

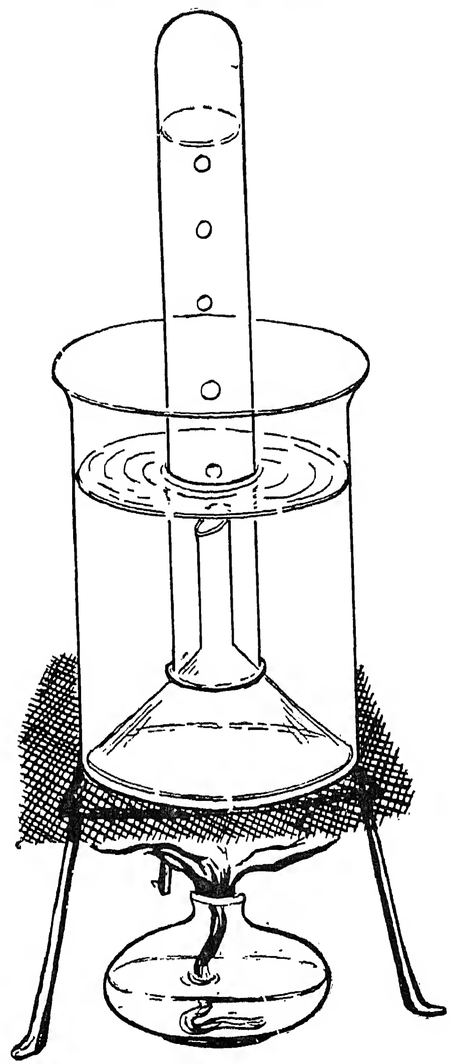


Fig. VII. 6. Dissolved gases in water.

Concept 1-b (p. 80): Oxygen is a constituent of water.

Set up an electrotype cell as follows.

Remove about 6 cm. of insulation from each end of two lengths of copper wire, each about 30 cm. long. Secure two gold point nibs from old fountain pens (or two pieces of aluminium strip) and wrap securely the uninsulated end of one of

the copper wires around each nib. Cover the joint with sealing wax so that no copper is exposed. Connect one wire to each terminal of a 6-volt battery (or 4 dry cells joined in series). Fill a dish half with water and carefully add about 2 table spoonsful of sulphuric acid to the water. Fill small bottles or test tubes with water, place a small glass plate over the mouths and invert them in the dish of water. Place each bottle on two two thin strips of wood over each pen point so that the mouth is raised from the bottom of the dish.

When all is ready, turn on the current. Observe after 20-30 minutes what happens in each bottle. Measure with a ruler the amounts of gas collected in each bottle. When the bottles are nearly filled, place a glass plate over the mouth.

Set the one which contains more gas mouth downwards and the other one with mouth upwards. Introduce a glowing splinter in the second bottle. What happens? This gas is oxygen.

Bring a lighted splinter to the mouth of the first bottle. What happens? This is hydrogen.

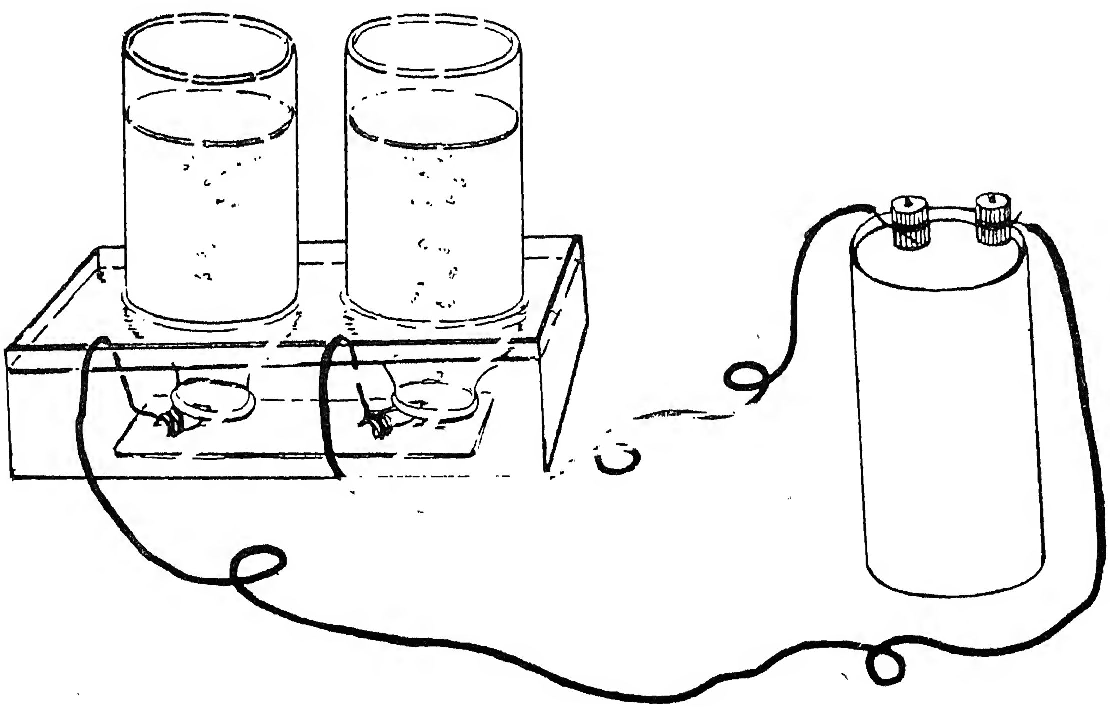


Fig. VII. 7. Components of water.

Concept 1-c, d **(p. 80)****:** (c) Oxygen is a constituent of most rocks and minerals.
(d) Oxygen is a constituent of most organic matter.

To show that oxygen is a constituent of rocks, minerals and most organic matter, it is best to show some charts and models of a few compounds like Silica (SiO_2), Borax ($Na_2B_4O_7 . 10H_2O$), Dolomite ($CaCO_3 . MgCO_3$), Feldspar ($KAlSi_3O$), Sugar ($C_{12}H_{22}O_{11}$), Alcohol (C_2H_5OH) and Acetic Acid (C_3COOH).

Using small pieces of iron wires and glass beads of different colours, (or little balls of plasticine), models of various minerals and compounds can be made.

Major Concept 2. Oxygen is obtained by heating some substances and by electrolysis of water.

Concept 2-a (p. 80) : It is obtained by heating certain oxides (red lead).

Oxygen may be prepared by heating red lead in a wide hard glass test tube placed in a horizontal position in a clamp stand. Attach a piece of glass tube bent as shown in Fig. VII.8 and collect the gas in cylinders (or test tubes) placed over a beehive shelf in a trough of water. Remember to take the delivery tube out of water before the heating is stopped.

Test the presence of oxygen by inserting a glowing splinter into the jar.

Concept 2-b (p. 80) : It is obtained by heating compounds like potassium nitrate, potassium chlorate and potassium permanganate.

Take the compounds one by one in hard glass test tubes and heat over a flame. When bubbles of gas start coming, hold a glowing splinter to show the presence of oxygen.

Concept 2-c (p. 80) : It is obtained by heating a mixture of manganese doixide and potassium chlorate.

1. Arrange the same apparatus as Fig. VII.8. Mix carefully one part of powdered manganese dioxide with 5-6 parts of powdered potassium chlorate. Place this mixture in the hard glass test tube and heat. Collect several jars of the gas formed. Take the delivery tube out of water before stopping the heating. Test for oxygen.

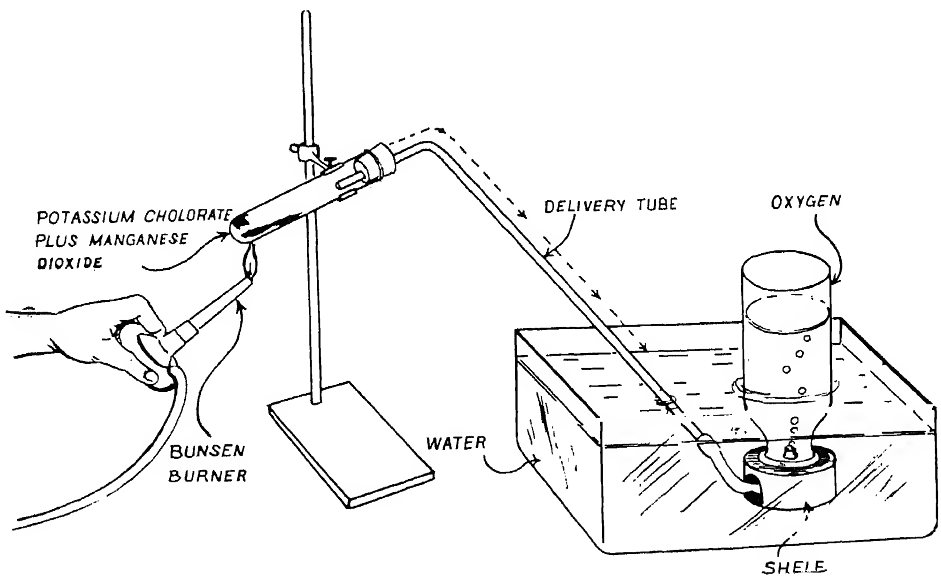


Fig. VII. 8. Preparation of oxygen.

Observe that by using manganese dioxide the oxygen is evolved more quickly than with potassium chlorate alone as in 2-b.

2. Another easy way of preparing oxygen is by the action of water on sodium peroxide.

Fit a dropping funnel in one hole and a delivery tube in the other hole of a cork of a dry round-bottom flask. Dip the end of the delivery tube in a trough containing water. Keep a beehive shelf over the end of the delivery tube. Put 10-15 gm. of dry sodium peroxide into the flask and put the cork in it. Keep the tap of the dropping funnel closed. Fill the funnel with water. Invert a gas jar filled with water over the beehive shelf. Allow water to fall drop by drop on the sodium peroxide. See that bubbles of gas are formed and collected in the gas jar.

Why should the first jar not contain pure oxygen?

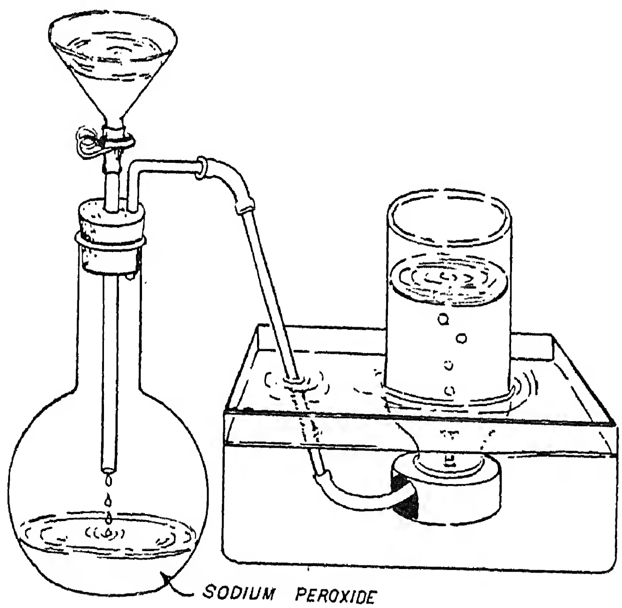


Fig. VII. 9. Preparation of oxygen.

Concept 2-d (p. 80): It is obtained by the electrolysis of water.

See 1-b above and Fig. VII. 7.

Major Concept 3. Oxygen is identified by its property of supporting combustion.

Concept 3-a, b (p. 80): (a) A glowing splinter introduced into a jar of oxygen bursts into flame.
(b) A burning candle will burn very brightly in a jar of oxygen.

Take any of the jars in which oxygen has been checked in the earlier experiment. Now do the following:

1. Incsrt a glowing splinter into the oxygen jar and observe that the splinter immediately bursts into a flame.

2. Fix a burning candle in a deflagrating spoon and plunge it into the jar and observe that it burns much more vigorously.

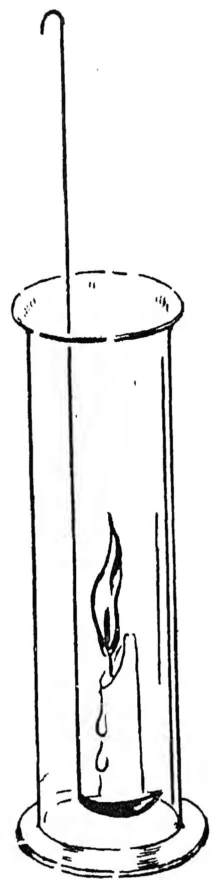


Fig. VII. 10. Oxygen supports combustion.

Major Concept 4. Oxides are formed when elements burn in oxygen.

Concept 4-a, b (p. 80): (a) Some of the oxides are acidic, turning blue litmus red.
(b) Some of the oxides are alkaline, turning red litmus blue.

An oxide is a compound of an element with oxygen. When things burn in air or oxygen, an oxide is usually formed.

Burn the following in separate gas jars in deflagrating spoons. When the burning has ceased, cover the jars with a glass disc. Take

sulphur, magnesium wire, phosphorus, charcoal, sodium and candle.

In each jar put a few drops of litmus solution and see how the colour of the litmus changes either to red or blue.

Those oxides which change the litmus to blue are called alkaline (magnesium, sodium). Those oxides which change the litmus to red are called acidic (sulphur, charcoal, phosphorus and candle).

Major Concept 5. Man uses oxygen in many ways.

Concept 5-a (p. 81): Oxygen can be stored and used for artificial respiration by persons not able to breathe oxygen from air normally, e.g.,

(i) mountaineers.
(ii) air men.
(iii) fire fighting squads.
(iv) patients.
(v) divers and crew in submarines.

1. Arrange a trip to a hospital where oxygen cylinders are used to aid respiration of patients suffering from the effects of drowning, asphyxia, pneumonia or failure of breathing.

Show the pupils the valves releasing the gas, and the masks, if any, for the patients. Explain how a large volume of gas is compressed in the cylinder as in a cycle tyre.

2. Show pictures of mountaineers, airmen, divers or submarine men and discuss how stored oxygen is helpful for their living in abnormal conditions. Also discuss the importance of oxygen to the fire fighters.

Concept 5-b (p. 81): Oxygen can be used to produce a high temperature to melt metals as in the oxy-hydrogen or oxy-acetylene flames.

To show the industrial use of oxygen, arrange a trip to a welding shop. Show how the oxygen and acetylene (or hydrogen) gases are released and mixed in the torch before burning. Show that the flame of the burning gas without the supply of oxygen is not particularly bright. As more and more oxygen is supplied, the flame becomes brighter and hotter. Show how the high temperature melts steel or metals. Discuss why workers use goggle shields for the eyes. Discuss the role of oxygen in producing the hot flame.

Hydrogen

Major Concept 1. Hydrogen is widespread at the surface of the earth.

Concept 1-a (p. 81): Hydrogen is a constituent of water.

1. Refer to sub-section on Oxygen 2-d.
2. Take a piece of sodium about the size of a pea in a wire gauze cage. Take a trough of water and place the wire gauze cage in the water. See that there is brisk effervescence. Collect the gas evolved by keeping an inverted test tube full of water over the cage. Take care that the mouth of the test tube is immersed in water.
3. Put a few pieces of magnesium ribbon or powder in a test tube of water. Keep it aside for half an hour. See bubbles of gas on the sides of the test tube and surface of magnesium.

Concept 1-b (p. 81): Hydrogen is a constituent of many rocks and minerals.

As in the case of oxygen, show charts and models of molecules of rocks and minerals containing hydrogen and let pupils construct some models with wires and beads. Some suitable examples are:

Gypsum	$CaSo_4 . 2H_2O$
Malachite	$Cu_2(OH)_2 CO_3$
Muscovite	$H_2(KNa) Al_3 (SiO_4)_3$
Talc	$H_2Mg_3 (SiO_3)_4$
Limonite	$2Fe_2O_3 . 3H_2O$

Concept 1-c (p. 81): Hydrogen is a constituent of all organic matter.

Take some common organic matter like wood chips, candle flakes, oils and fats, cereals, sugar, etc., in a deflagrating spoon and heat each so that it starts burning. As it burns, hold a test tube containing cold water over the flame. See that a fine deposit of water vapour collects.

Knowing that water is a compound of hydrogen it can be seen that hydrogen must have come from the organic compound itself.

Concept 1-d (p. 81): Hydrogen is a part of all acids.

To show that hydrogen is a part of acids, take dilute sulphuric or hydrochloric acid in a test tube and drop a few pieces of granulated zinc in it. See that there is a brisk evolution of gas.

Bring a burning splinter near the mouth of the test tube. See that the gas burns with a slight popping sound. This is a test for hydrogen.

Major Concept 2. Hydrogen is prepared from water or acids.

Concept 2-a (p. 81): Hydrogen is prepared by electrolysis of water.

Refer to sub-section on Oxygen 2-d, and refer to Fig. VII. 7.

Concept 2-b (p. 81): Hydrogen is prepared when dilute hydrochloric acid is added to zinc.

Take a flat bottomed flask or a bottle with a closely fitting two-holed cork. Through one hole pass a thistle funnel. Through the other pass a bent delivery tube as shown in the figure. Arrange a trough with water and a beehive shelf to collect gas as usual.

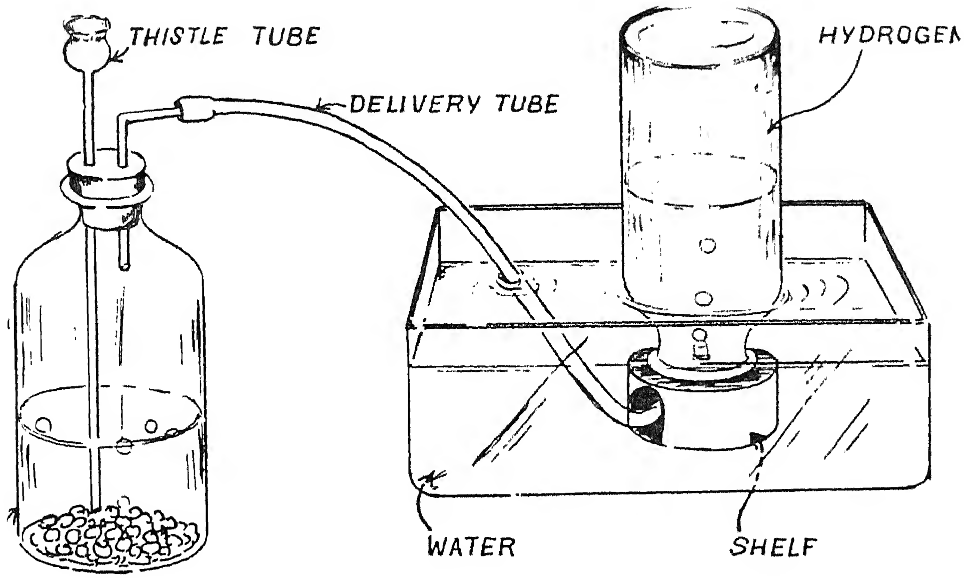


Fig. VII. 11. Preparing hydrogen (1).

Put some granulated zinc pieces in the flask and cover them with water. Cork the flask tightly and see that the end of the thistle funnel remains dipped under water. Through the thistle funnel pour hydrochloric acid in small quantities at a time.

Observe the brisk evolution of gas. Collect the first part in test tubes filled with water and inverted over the beehive shelf. Test the gas by bringing the mouth of the test tube near a spirit lamp or burner. See whether it burns with an explosion or burns quietly. Go on collecting test samples in test tubes until the gas burns quietly. Then fill a few jars with pure hydrogen.

Concept 2-c (p. 81) : Hydrogen can also be prepared by the action of magnesium or sodium on water.

1. Cut a piece of sodium about the size of a large pea. Dry it between folds of blotting paper. Enclose it in a sodium spoon or make an improvised wire gauze cage. Put the sodium in it. Take a trough of water and keep a few jars filled with water and inverted in the trough ready for gas collection. Then put the piece of sodium in the water and collect the gas evolving vigorously in gas jars.

Discuss the reason for putting the pellet of sodium in the wire cage.

By the action of litmus show that the residual water has become alkaline. Thus an idea of what chemical change has taken place may be given.

2. Take some magnesium powder in a hard glass tube about 30 cm. long. At each end fit a cork with a tube as shown in Fig. VII. 12. Connect one end with a round bottomed flask half full of water, used as a boiler. Connect the other end

with a delivery tube to collect gas by displacement of water as in previous experiments.

Heat the boiler so that steam starts coming and then heat the tube below the magnesium. Before collecting the gas in gas jars, first take test samples in test tubes. Determine whether pure hydrogen or an explosive mixture of hydrogen and air is coming. Then fill several jars with the gas.

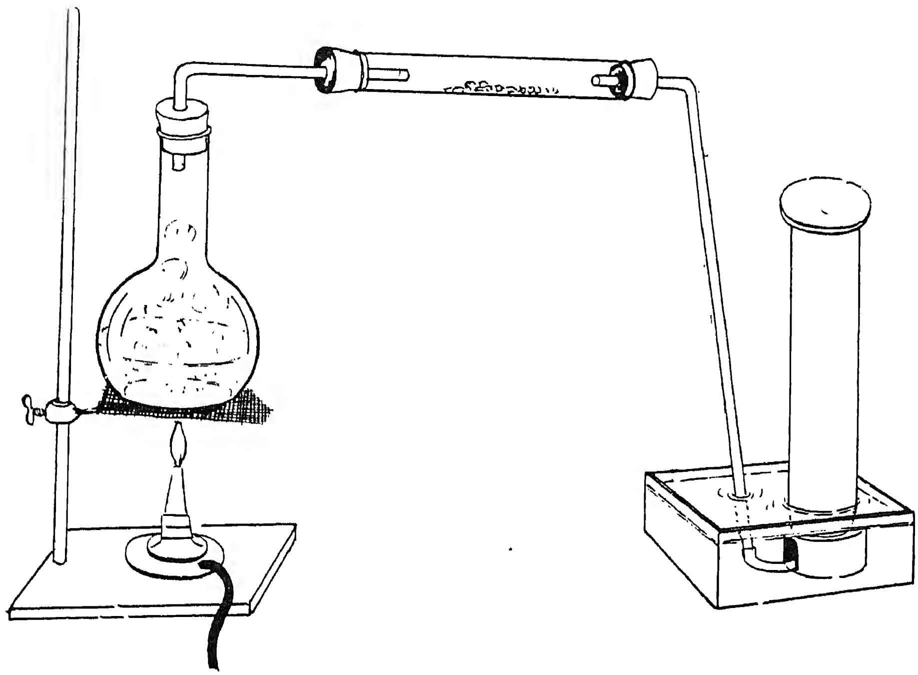


Fig. VII. 12. Preparing hydrogen (2).

Major Concept 3. Hydrogen combines with other elements to form many compounds.

Concept 3-a (p. 81) : Water is formed when hydrogen is burnt.

Fit up a hydrogen generator in a bottle with a thistle funnel and a delivery tube. Fit the delivery tube to a U-tube filled with calcium chloride. Fit a jet to the other end of the U-tube. Put zinc granules and a little water in the generator. Make all joints air-tight. Pour dilute hydrochloric or sulphuric acid through the funnel and bring a match stick near the jet of the issuing

gas. When the jet starts burning, hold a bell jar as shown. Collect the water formed. A drying tube is desirable but not essential.

Observe the colour of the flame of hydrogen.

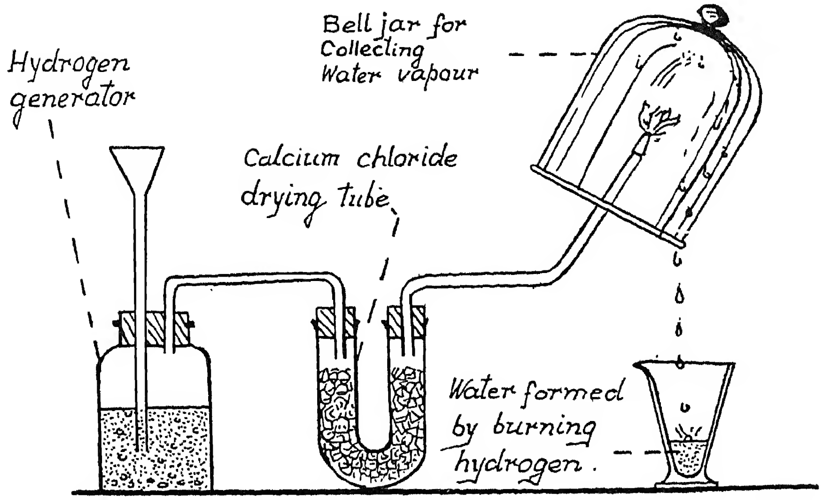


Fig. VII.13. Burning hydrogen in air produces water.

Concept 3-b (p. 81): Hydrogen combines with chlorine to form hydrochloric acid.

The following demonstration should be done by the *teacher only*. Prepare a few jars of chlorine by the reaction of dilute hydrochloric acid on bleaching powder in the same apparatus as you use for preparing hydrogen (Fig. VII. 13). Then clean and wash the apparatus and use it to prepare a few jars of hydrogen. Use a piece of thin glass or cardboard to cover each jar.

Complete the demonstration in a dark room because chlorine and hydrogen react vigorously with each other in sunlight and bright light.

Take one jar of chlorine and one equal jar of hydrogen. Place the jar mouths together and slide out the covers from between the jars. Ater a few minutes, separate the jars and replace the covers. Test the contents as follows:

(a) Blow across the mouth of one jar. A fog will be produced which helps you identify the gas as hydrogen chloride.

(b) Test the dry gas in either jar with blue litmus paper, then add a little water to the jar and test again with litmus. This water solution is *hydrochloric acid*. Did blue litmus change to red this time? Did it change to red in the dry gas? Does the gas in each jar react the same way? What do you conclude about hydrogen and chlorine?

Great care should be taken in this demonstration. Chlorine should not be inhaled. Even small quantities are irritating to nose, throat and lungs.

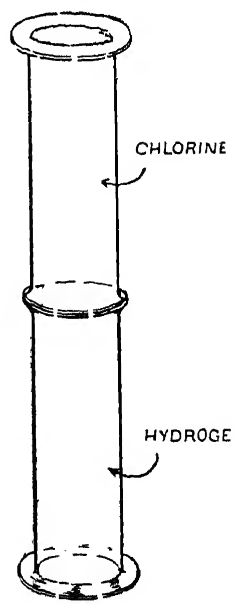


Fig. VII.14. Hydrogen has affinity for chlorine.

Major Concept 4. Hydrogen has characteristic properties.

Concept 4-a (p. 81): Hydrogen is the lightest gas.

1. Take two jars of hydrogen prepared earlier and two empty jars (that is, containing air). First keep one jar of hydrogen over a jar of air with the glass cover on it (jars 1 & 3). Place the second jar of air over the second jar of hydrogen with the cover on (jars 2 & 4). After allowing the jars to stay for a few minutes, carefully remove the glass cover so that the gases have a chance to mix. After a minute, separate the four jars, each covered with its lid.

Test the presence of hydrogen by bringing a burning splinter near the mouth of each jar by turns. Record the observations as follows:

	Jar No.			
	1	2	3	4
Check if hydrogen is present				

2. Connect a clay pipe by means of a rubber tubing with a hydrogen generator. Prepare a bowl of soap water to which add a few drops of glycerol. Now use the stream of hydrogen to blow soap bubbles. Shake the soap bubbles loose and see how they rise to the ceiling.

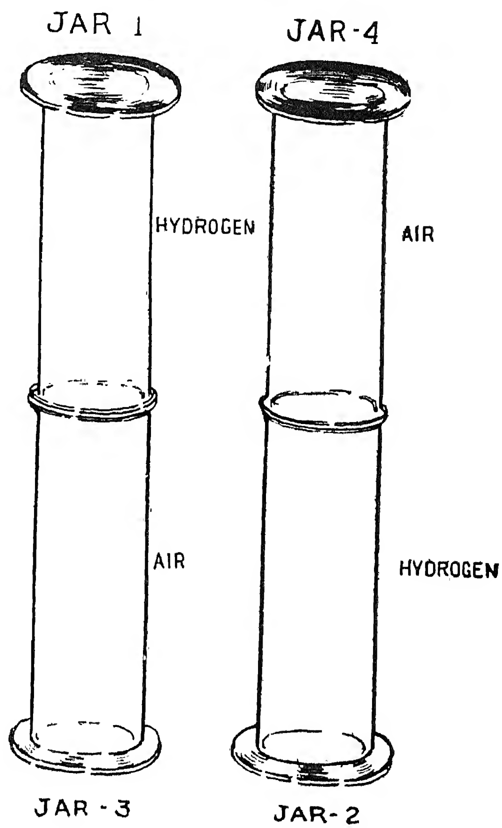


Fig. VII.15. Hydrogen is lighter than air.

Concept 4-b (p. 81): Hydrogen is combustible and burns with a pale blue flame.

Refer to experiments of 3-a. See Fig. VII. 13.

Concept 4-c (p. 81): Hydrogen does not support combustion.

To show that hydrogen does not support combustion, take a gas jar full of hydrogen, with its open end pointing downward. Light a long thin wood splinter, open the gas jar cover and

insert the burning splinter well inside the jar. Observe that it is extinguished immediately, though the gas burns at the mouth of the jar.

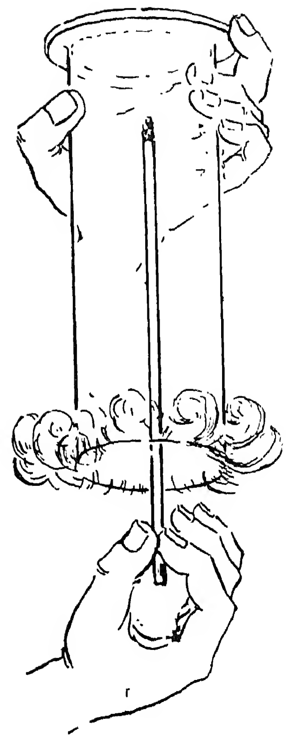


Fig. VII.16. Hydrogen does not support combustion but it burns.

Major Concept 5. Hydrogen is used in many ways.

Concept 5-a (p. 82): Hydrogen is used by meteorologists in balloons.

Fill a toy rubber balloon with hydrogen from a cylinder of hydrogen gas. Such cylinders are found in welder's shops or with balloon sellers. Tie a thin thread to the hydrogen filled balloon and allow it to go high up in the sky.

Discuss its possible use by meteorologists in finding out about the atmospheric conditions in the upper air and also in finding the direction and velocity of wind.

Concept 5-b (p. 82): Hydrogen is used in welding (oxyhydrogen flame).

Visit a welding shop as referred to in concept 5-b under 'Oxygen'.

Concept 5-c (p. 82): Hydrogen is used in the hydrogenation of oils.

To explain the use of hydrogen in hardening vegetable oils, refer to the labels of the containers of hydrogenated oil available in the market. Show by passing hydrogen gas from a generator into a liquid oil that no change really occurs. Then explain that only at a certain temperature and pressure and in the presence of finely divided nickel powder, can hydrogen be made to combine with liquid oils to make solid fats.

Develop the ideas of catalysis and saturation.

Carbon Dioxide

Major Concept 1. Carbon dioxide is formed by the union of carbon with oxygen.

Concept 1-a, b, c, d (p. 82): (a) It is formed when any carbon fuel burns.
(b) It is formed when any organic matter decomposes.
(c) It is formed when sugar solutions ferment.
(d) It is formed when respiration occurs.

1. To show that when a fuel containing carbon burns or a living thing respires, carbon dioxide is given off, first show that if a little lime water is shaken in a gas jar containing air, it does not change its colour.

Then light a candle, fix it on the cover of a gas jar, and finally invert the gas jar over the lighted candle. When the candle is put out, invert the gas jar and carefully pour a little clear lime water by moving the lid a little on one side.

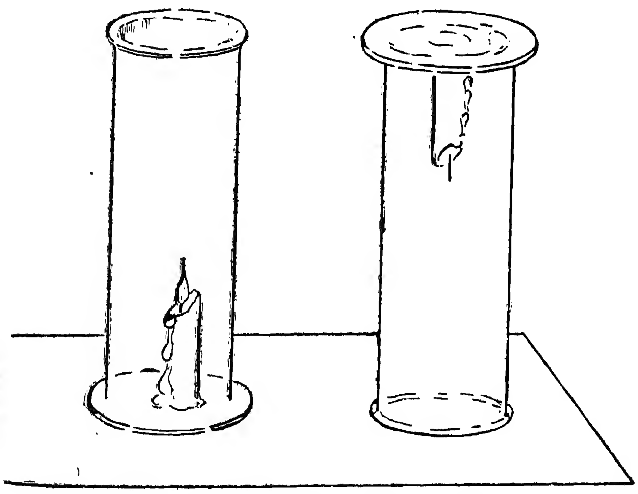


Fig. VII.17. CO_2 is formed during combustion.

Shake the jar and see whether the lime water is clear as it was or has changed.

Explain that carbon dioxide gas makes lime water milky as it combines with lime to form a new substance called 'chalk' or 'calcium carbonate.' Repeat this experiment by burning other organic matter.

2. To show that respiration produces carbon dioxide, take a test tube with a little lime water in it. Breath out air through the lime water with a soda straw or a glass tube. See if the lime water turns milky or not.

3. To show that when sugar ferments, carbon dioxide is formed, take a flask containing sugar solution, add into it a spoonful of 'khamir' or 'toddy' or a pinch of brewer's yeast. Cork the flask and keep it in a warm place.

After a few hours, observe the froth formed. Take a long glass tube in which a drop of lime water is held by the tip of the finger above, and

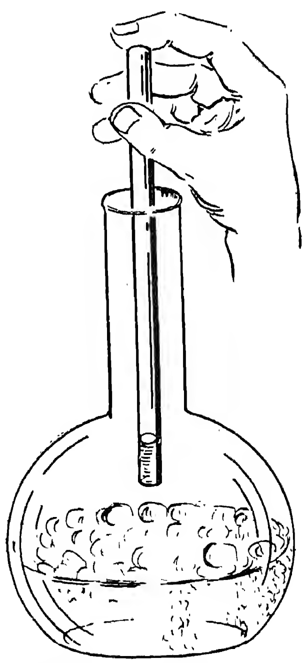


Fig. VII.18. CO_2 is formed when sugar ferments.

insert it carefully into the flask. See if there is any change in the lime water. Also insert a burning splinter into the flask. Does it continue to burn?

4. Draw attention to the effervescence produced when things are rotting.

5. Show the spongy texture of a loaf of bread as a result of formation of carbon dioxide while baking.

Major Concept 2. Carbon dioxide is prepared from carbonates.

Concept 2-a (p. 82) : When limestone is heated strongly, it changes to quicklime and carbon dioxide.

To show that limestone, marble, chalk or mollusc shells (all being forms of calcium carbonate) change to quicklime and carbon dioxide, take any one of these in a crushed form in a hard glass test tube and heat strongly over a flame.

Hold a glass tube containing a drop of lime water carefully inside the test tube without touching the side or the contents, as in the previous experiment. Does the lime water change colour?

Now examine the residue left in the test tube. Pour it on a dish. Add a few drops of water and see if it becomes warm. Bring in turn a moist blue and a red litmus paper into contact with the residue and note the changes if any.

The limestone (which is a form of calcium carbonate) has changed into quicklime, an alkali and carbon dioxide.

Concept 2-b (p. 82) : Carbon dioxide is formed by adding acids to limestone, marble, washing soda or baking soda.

1. To prepare carbon dioxide by action of an acid on a carbonate, set the apparatus as shown below. Place some marble chips (or washing soda) in the bottle and cover with water. Close the bottle, arrange the gas jar and then carefully pour hydrochloric acid a little at a time through the thistle funnel.

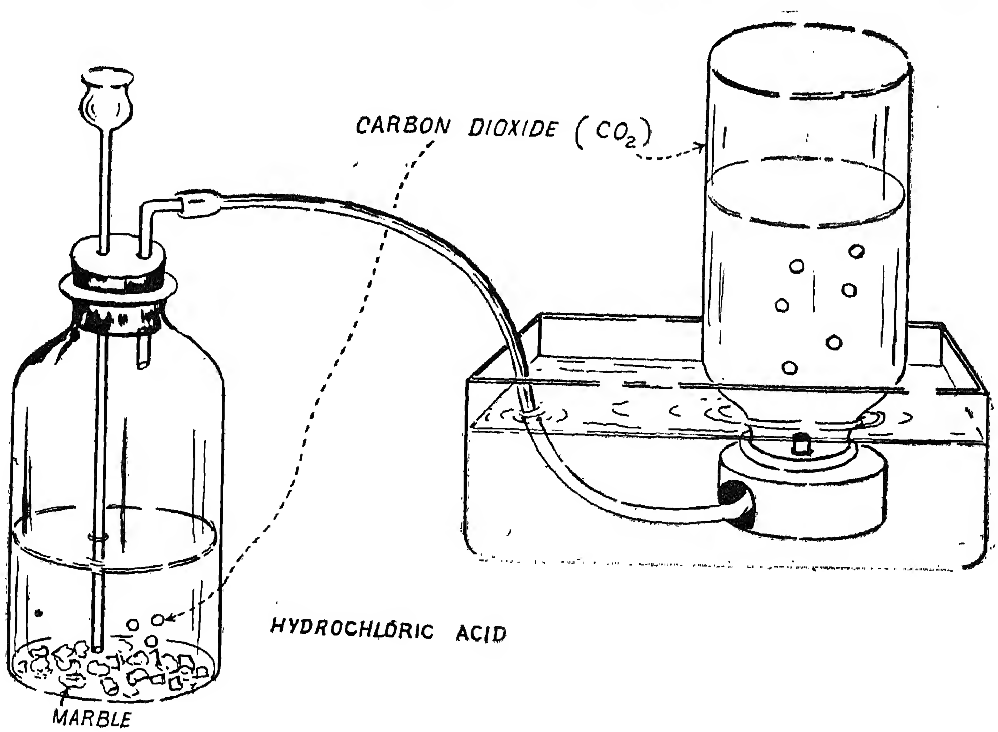


Fig. VII.19. Preparing carbon dioxide.

To test that the jar is full of carbon dioxide, bring a lighted splinter near the mouth of the jar. If it is extinguished, the jar is full. Why? When a jar is full, cover it with a glass disc, set it aside, and collect another jar.

2. Let pupils bring collections of rocks and test them with dilute hydrochloric acid to find out which of them are carbonates; that is, to see if they produce effervescence with the acid.

Major Concept 3. Carbon dioxide has characteristic properties.

Concept 3-a, b, c, d, e (p. 82):

(a) Carbon dioxide is heavier than air.
(b) Carbon dioxide is not combustible.
(c) Carbon dioxide is a non-supporter of combustion.
(d) Carbon dioxide turns lime water milky, which is a test for this gas.
(e) 'Carbon dioxide dissolves in water to give a weak acid called 'carbonic acid.'

First prepare several jars of the carbon dioxide as before.

1. Arrange four or five small candles on a long wire hook as shown in the figure. (Candles in a trough may be used, also).

Light the candles. Suspend the hook on some point. Then carefully pour a jar full of carbon dioxide as illustrated. Is there any effect on the candles? In what order is the effect observed, from top to bottom or otherwise?

What two properties of carbon dioxide are indicated in this experiment?

2. Plunge a burning splinter into another gas jar. Find out whether the gas starts burning or not. Does the splinter continue to burn? Why?

3. Pour a few drops of lime water into another jar. Close the lid and shake. What is the colour of the lime water now?

4. Open a soda water bottle and test the gas coming out by holding a drop of lime water near the mouth. Show that the gas had remained dissolved in water under pressure so long as the bottle was closed, but when the lid was taken off, the pressure was released and the carbon dioxide escaped.

5. Place a moist blue litmus paper in a jar and shake the jar. See if the colour remains the same or is altered. What does it indicate?

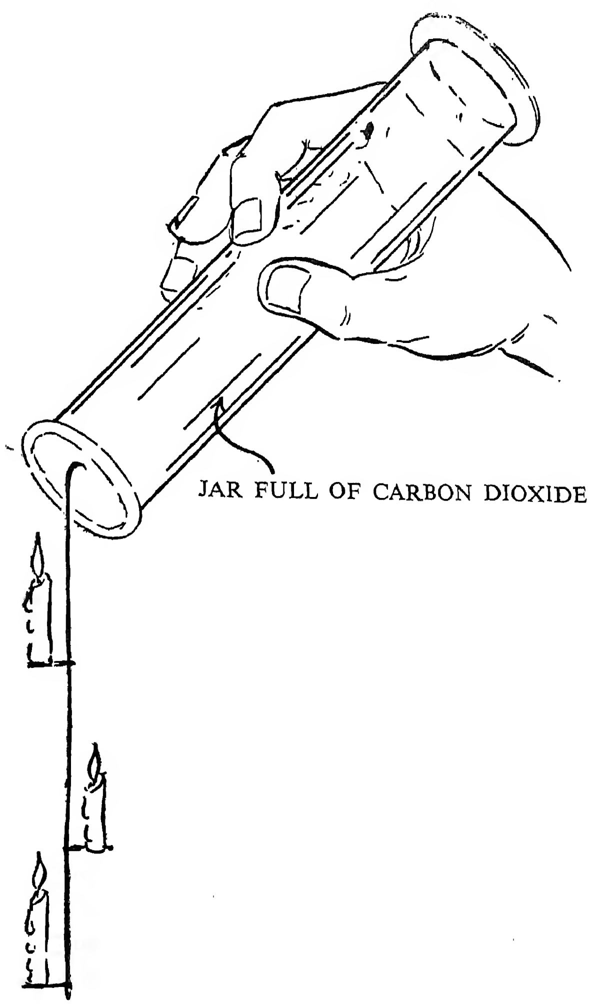


Fig. VII.20. Carbon dioxide does not support combustion.

Major Concept 4. Carbon dioxide is used in many ways.

Concept 4-a (p. 82): It is used in extinguishing fires.

To show the use of carbon dioxide in extinguishing fires, make a model of a chemical fire extinguisher.

Half fill an old ink bottle with sodium bicarbonate solution. Fit it with a one-holed cork through which a glass tube of about 7mm. outside diameter bent at right angles is passed. The end outside the bottle should be a jet. Take a few ml. of sulphuric or acetic acid in a pill bottle and tie a thread to it. Close the acid bottle with a cork from which a sector has been cut to make the acid come out slowly. Suspend the thread through the cork and close it tightly.

To operate the fire extinguisher, invert it.

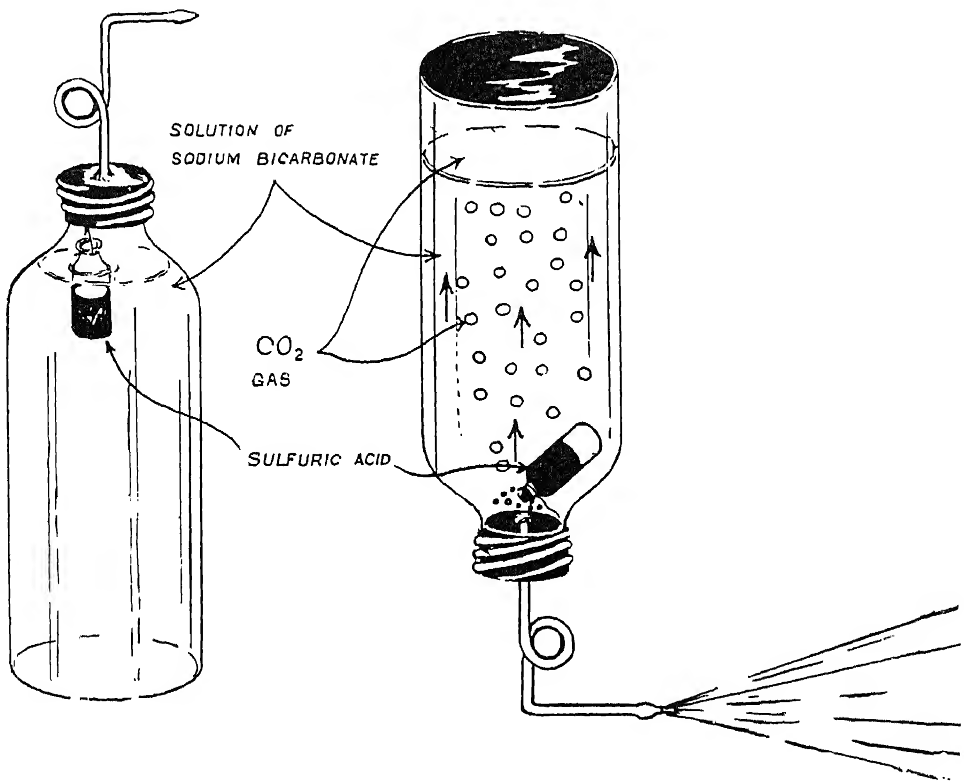


Fig. VII.21. Home-made fire extinguisher.

Concept 4-b (p. 82): It is used in making aerated carbonated water.

Take the pupils to an aerated water factory or to observe a portable carbonating machine seen in fairs. Open a bottle and test for carbon dioxide gas released. Some idea of the increase of solubility of a gas under pressure might be given in this reference.

Concept 4-c (p. 82) : It is used as a refrigerant (dry ice).

If dry ice is available, this may be demonstrated.

Concept 4-d (p. 82) : It is used to inflate safety belts and rafts.

The importance of using carbon dioxide for use in safety belts and rafts may be associated with its property of non-combustibility.

Major Concept 5. Plants maintain the balance of carbon dioxide in air.

Concept 5-a, b, c, d (p. 82) :
(a) Carbon dioxide is continuously added to the air by burning and by respiration of every living creature.
(b) Carbon dioxide is continuously removed from the air by green plants in the process of photosynthesis.
(c) Within limits, as the carbon dioxide content of the air increases, the rate of photosynthesis increases and plants grow more luxuriously.
(d) The carbon dioxide content of air thus remains at a constant level (.04%).

Refer to experiments under concept 1-a (Air) and 1-a (Carbon dioxide) to explain the constant addition of carbon dioxide to air.

Find from reference books on chemistry the fact that the carbon dioxide content of air is fairly constant at 0.04%.

Recall the process of photosynthesis by green plants where carbon dioxide is absorbed by plants.

Then discuss why luxuriant growth of green plants will restore the balance of carbon dioxide when the content of carbon dioxide is increased.

Acids, Bases and Salts

Major Concept 1. Acids have certain properties in common. Hydrochloric, sulphuric, nitric and carbonic are a few common acids.

Concept 1-a,b,c,d (p. 82) :
(a) Acids turn blue litmus paper red.
(b) Acids are sour to taste.
(c) Acids generally dissolve metals giving off hydrogen and forming salts.
(d) Acids neutralize alkalies forming salts and water.

To show the common properties of acids, take solutions of dilute sulphuric, hydrochloric, acetic and citric (lemon juice) acids in different vessels.

1. Dip a piece of red and blue litmus in each and see what the change is.

2. Take a droplet of a very dilute solution

hydrochloric, acetic and citric acids each in turn at the end of a washed glass rod and taste each. What is the taste ?

3. Drop a few pieces of zinc or magnesium into a dilute solution of hydrochloric acid and see if there is effervescence. Correlate this with your study of hydrogen.

4. Add drop by drop to a solution of any acid a caustic soda solution. Test periodically with litmus paper. This phenomenon of neutralization can also be demonstrated with sodium carbonate (washing soda) solution. After neutralization of hydrochloric acid with caustic soda, evaporate the solution to dryness. See what residue is left. Taste a fine particle from it. How does it taste ? This is sodium chloride, or common salt.

Major Concept 2. Alkalies have certain properties in common. Sodium hydroxide and potassium hydroxide are strong alkalies. Calcium hydroxide and ammonium hydroxide are mild alkalies.

Concept 2-a,b,c (p. 82): (a) Alkalies turn red litmus paper blue.
(b) Alkalies are caustic to taste, and feel soapy to touch.
(c) Alkalies neutralize acids forming salts and water.

To show different properties of alkalies, take solutions of caustic soda, lime, and/or ammonia in different beakers.

1. Dip pieces of red and blue litmus papers in the solutions and observe the change of colour.

2. Take a little sample of each in separate test tubes and pour into each a drop of phenolphthalein solution. Observe the change that takes place.

3. With the help of a clean glass rod have a drop of the dilute alkali on your finger tip; rub and then wash your hand. How does it feel to the touch ?

4. To the solution of an alkali (say, ammonia) add a drop of phenolphthalein and then add small amounts of diluted acid (say hydrochloric acid) until the pink colour just disappears. Is the solution still alkaline? Test if it is acidic. Evaporate the solution to dryness. What is the residue composed of ? (ammonium chloride).

Explain the phenomenon of salt formation and introduce the nomenclature of the salts.

Materials in Daily Use

Major Concept 1. Glass is an indispensable material in modern life.

Concept 1-a (p. 83): Glass is made by heating together sand, washing soda and limestone.

1. To show the formation of glass, take a nichrome wire loop on a glass rod. Heat it over a spirit lamp flame and dip it in a little sodium carbonate which melts and remains stuck to the wire loop. While still hot, quickly dip it in powdered silica or dry sand and heat strongly on the flame to get a clear transparent glassy bead.

2. If a blast lamp (pressure type used by

jewellers) is available, glass can be made in a small metal crucible, using powdered limestone, fire-sand and washing soda as raw materials.

Use 177 gm. of sand, 67.6 gm. of sodium carbonate, and 31 gm. oz. of limestone or chalk. Heat on a very hot flame.

3. Visit a glass factory or a college chemical laboratory where glass-ware is blown or worked.

Concept 1-b (p. 83): Glass is transparent, a poor conductor of heat, but is brittle and is easily broken.

1. Show the transparency of glass in ordinary sheet glass, lenses, and prisms.

2. Heat a 15-20 cm. long glass rod on a flame and see that you can still hold it at the other end without burning your fingers.

3. Draw attention to common experiences to show the brittleness, easy fusibility, electric insulation (bulbs), mirroring, hardness etc., of glass.

Concept 1-c (p. 83): Waste glass can be used again as raw material for the manufacture of glass.

Melt some waste or broken glass in a metal crucible as in concept 1-a above.

Concept 1-d (p. 83): Glass is used as a building material, a decorating material, and in various articles of domestic use.

Ask pupils to report as many uses of glass as they can think of. A committee may classify the items into various categories.

Major Concept 2. Porcelain is used for many purposes.

Concept 2-a (p. 83): Porcelain is made from kaolin.

Make a field trip to a potter's place to see how ordinary clay is used to make earthenware on the potter's wheel. Then observe how earthenware pots are fired and, if necessary, glazed.

Show them some china clay or kaolin. Mix some finely divided quartz with kaolin and a little feldspar. Knead it with water to make a heavy plastic mass. Shape it into a suitable vessel and have it baked at the potter's oven.

Concept 2-b (p. 83): Porcelain vessels can be glazed and decorated.

Show that the product obtained is somewhat porous and differs from the glazed potters that is used in the home. Again explain the importance of quartz and salt while firing. For decorations, coloured designs are made or stencilled and a second coating of glaze is given, and then the object is fired.

CLASS VIII

Major Concept 1. Metals occur in nature as elementsor in a combined state.

Concept 1-a **(p. 83)****:** Gold and sometimes silver occur as free elements.

1. Just what do we mean by a metal ? No doubt when you hear the word metal you think of a coin, a copper bowl, a ring, a necklace. Metals are all around you, in water pipes, pins, needles and bridges, in land and in buildings. When you switch on a light or a radio, the bulbs or tubes are lit because of a filament made from a metal. When you drive in a car or taxi you are almost enclosed by metals. When you ride on a train, you are on steel (iron) rails.

2. Make a list of the metals most common in your daily life. Which of these can be found in a natural state as *elements* and which occur in ores, from which the metal must be separated? Observe metals like lead, copper, iron, gold, etc. Compare things which you know are made from such metals with the metals in the crude state.

3. If you observe metals carefully, you can find out some of their characteristics. Think of copper wire in electrical wiring. Put a silver teaspoon in your hot tea. Feel how hot it is. Most metals are good conductors of heat and electricity.

Metals can be drawn into wire or rolled into thin sheets as gold or tin foil.

In their pure form, metals are bright and shiny. You may think lead is dull, but if you break open a bunch of lead it will glisten on the inside.

You have noticed how quickly iron combines with the oxygen of the air. We say it rusts. Find the metals that do not rust easily in air. (Check on aluminium, copper, nickel, tin, zinc, lead, silver, gold, mercury.)

Find some reasons why we consider the 'national' metals, gold and silver, precious. Do they corrode? Do they rust? Are they very useful? As early as B.C. 3500 gold was used for ornaments and plates.

Other so-called precious metals such as platinum and uranium are found in a pure form in the natural state.

Discuss why there is still so much gold in the sea. Find a map to help you locate the gold fields of the world.

Concept 1-b **(p. 83)****:** Other metals occur as ores from which they are extracted.

How is a metal separated from the ore? Take some lead oxide, a block of charcoal, a blowpipe, and a source of heat such as a bunsen burner (stove). Make a little hollow in the block of charcoal and place in it a little lead oxide. With the blowpipe blow the flame against the oxide.

Describe the changes in the lead oxide.

If the metal is combined with sulphur or carbon, the ore is roasted or heated in the air. The sulphur or carbon burns or combines with the oxygen of the air.

Fig. VII. 22. How is metal separated from its ore?

Major Concept 2. Extraction of gold is a process of concentration and separation of the metal from the sand or hard rock.

Concept 2-a (p. 84): Gold nuggets occur in some rocks.

Read all you can about mining gold. These stories make exciting reading. Compare mining gold in the olden days with the mining of today.

Scientists believe that most ore deposits come from liquid given off by cooling molten rock (magma) deep in the earth. Ores containing liquids work their way along cracks in the earth's crust. As they cool, ores containing metals are deposited in the cracks. This deposit is called a vein. Copper, silver and gold collect in this way.

Scattered deposits of various sized particles are often washed deeper and deeper to where they may reach hard rock and form an ore deposit of scattered particles called a 'placer.' Here *nuggets* are found.

Read about placers and the hydraulic mining of gold.

Concept 2-b, c (p. 84): (b) Most gold is found as fine grains in alluvial sand.
(c) The heavier gold particles are separated by washing with moving water.

Try panning for 'gold'. In nature, powdered gold and sand are the ingredients, but for your experiment, mix some sand and powdered clay or a little crushed old brick. Mix in some bits of solder, a few pieces of wire, tacks and some iron filings. Pour a cupful of this mixture into a quart

jar half filled with water. Shake it well. Let the sediment settle. Do the materials settle in layers? Which settles out first? Particles of gold from veins where the rocks have weathered away may be moved by rain and become part of streams. Since gold is nineteen times as heavy as water, where do you expect to find the gold? The gold particles can be separated by washing with moving water.

Fig. VII.23. Panning for gold.

Major Concept 3. Iron is separated from its oxide ore by reducing at a high temperature with coke and limestone.

Iron is mostly found in nature combined with oxygen in the form of oxide, or with sulphur in the form of a sulphide. We call these 'compounds.' The best known ore of iron is a red iron oxide, haematite.

Iron has been found in a pure state in meteorites (meteors which fall to earth).

List all the ways you use iron in your life. Do not forget your food, magnets, and tools. Have you ever seen a piece of iron called 'lodestone' ? Find out about lodestone.

Make a map of the world. Show where iron is found.

How is iron separated from its ore? Do you live near a place where there is a forge? Observe men at work in a forge with bellows, anvil, and heavy hammers.

Quite by chanceprimitive man discovered that iron left in contact with red-hot charcoal would absorb carbon and be changed to a metal for making tools and weapons. Primitive man thus made the first carbon steel. He could never produce the temperature high enough to produce a liquid metal,—1535° Centigrade.

Concept 3-a,b,c,d,e (p. 84):
(a) Pig iron is obtained when these raw materials are heated in a blast furnace.
(b) Coke burns to produce a high temperature. It combines with the oxygen of the ore, leaving the metal free.
(c) The limestone combines with the rock impurities and removes them as a molten slag.
(d) A blast of hot air is blown into the furnace to hasten combustion.
(e) The hot gases from the furnace are used to heat the blast of air.

Try to imagine how hot a blast furnace would need to be to melt iron. Is it possible to visit an iron mine? A steel mill? If someone has visited these places, let him describe the visit. Look at

the picture of the blast furnace. A blast furnace makes *pig iron.*

See how high the stack is. This is a tall iron tower, 50-100 feet high lines with fire brick. A mixture of iron ore and *coke,* which produces intense heat is added at the top. At the bottom is the hearth on which the liquid iron and slag collect. Just above the hearth is a ring or jet (T) through which a blast of hot air is blown into the furnace. The coke (carbon) burns to a point where a chemical action between the ore and the coke takes place. Oxygen leaves the ore and unites with carbon forming carbon dioxide. The iron is freed from the ore and sinks to the bottom. The melted limestone which has soaked up most of the impurities of the ore floats above the molten iron as slag. The iron is drawn from the furnace and allowed to cool in moulds or "pigs". These moulds are something like the sanboxes, children play in. Their very shape reminds one of a mother pig with family and so the name "pig iron" has been given.

Tell how in the experiment with lead oxide and the blowpipe, you hastened combustion. Relate this to the use of jets of hot air blown into the furnace.

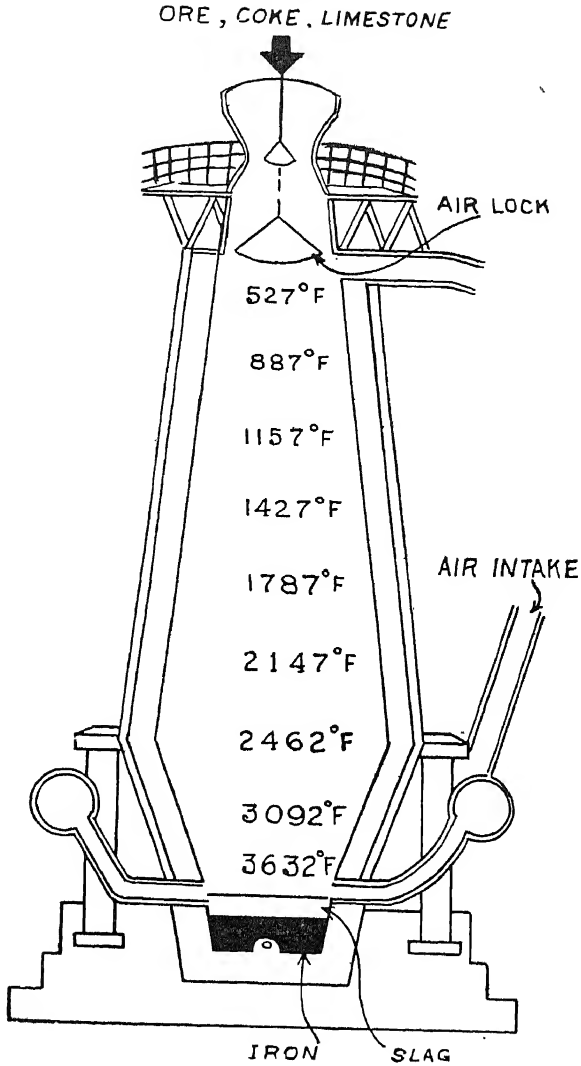


Fig. VII.24. Blast furnace.

Concept 3-f (p. 84): Cast iron and wrought iron are obtained by heating and burning the carbon out of pig iron in a furnace.
(i) Cast iron contains quite a bit of carbon.
(ii) Wrought iron is nearly pure iron.

What is *cast iron?* Describe *wrought iron.* Why do you not expect cast iron to be used for wire, rods, or thin sheets as wrought iron is used? Perhaps some of the solid bases of stands in your laboratory are made of cast iron. Compare the quantities of iron and of impurities in cast iron and in wrought iron (about 92% to 99% iron.) Which would you say is nearly pure iron?

Concept 3-g (p. 84): Carbon steel may be made by burning nearly all the carbon out of the pig iron in a Bessemer furnace.

Read the story of Englishman Bessemer and his idea of burning off the impurities of pig iron by blowing cold air through the liquid mass. Oxygen in the air combines with the impurities in the pig iron. William Kelley, an American, was considered crazy because he too thought of this process. Do you recall that often great ideas of science are not at once accepted ?

The patent issued to Bessemer for this process began what we call the Steel Age.

Find out about the four types of processes used to make steel—open hearth, Bessemer, electric, and basic oxygen. Draw illustrations to show the different types.

Concept 3-h (p. 84): Different steels are made by burning nearly all the carbon out of the pig iron in a furnace and then adding the requisite amount of carbon or one or more other metals such as nickel, chromium, cobalt, manganese or silicon.

Study the world map to find from where various elements used in improving steel come. What elements does India have?

Manganese, very important in steel making, improves the strength and aids in the removal of oxygen. Find out what nickel, cobalt, chromium, tungsten and refined nickel, do to improve steel with regard to its qualities such as hardness, toughness, corrosion resistance, retaining cutting edges at high temperatures, and improving electrical qualities. Find out about stainless steel. For what is it used? Why is it in such demand?

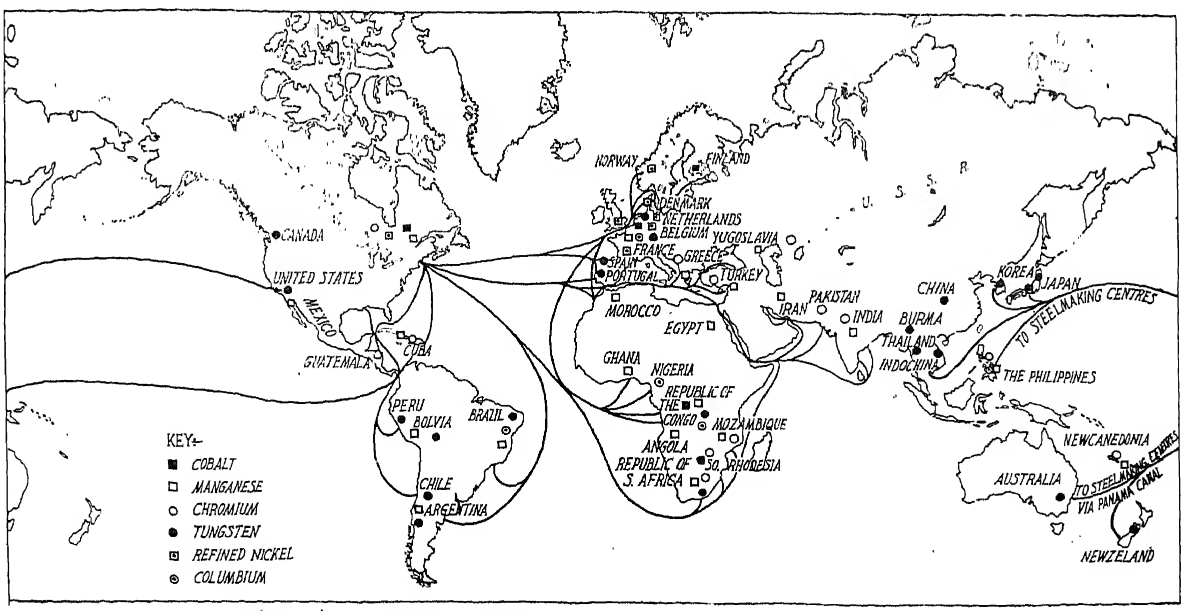


Fig. VII.25. World distribution of elements for steel making.

Concept 3-i (p. 84): Scrap iron is also used in making steel. It is a source of the particular metals needed. Scrap iron should be consumed.

Did you ever think that the bicycle, the automobile or scooter you saw smashed up would be used again? Find out how scrap iron is used in the steel making process. If you are near a steel manufacturing area, visit the steel plant.

Major Concept 4. The passage of electricity through some compounds, or solutions of compounds, separates the compound into its elements. This process is called 'electrolysis.'

In your search for materials, you have discovered some that are easy to take apart and others are difficult to take apart. You know that chemists express the chemical structure of a substance by a formula. All compounds are composed of atoms. Elements are composed of atoms. Atoms are combined in molecules. Each kind of molecule has a different chemical formula. The formula shows how the atoms in the molecule are combined. Suppose the atoms in a molecule were arranged differently, would you then have the same substance?

Can water be taken apart? How will the new molecules that are formed be different from the water molecule? What is the structure of the water molecule? Its formula is H_2O, or two hydrogen atoms to one oxygen atom. Chemists believe that all atoms are held together by electrical attraction. Now if we wish to get these atoms apart, we will have to supply enough energy to overcome this attraction between hydrogen and oxygen atoms in the water molecule.

Concept 4-a (p. 85): During the electrolysis of water, hydrogen is released at the negative electrode (cathode) and oxygen is released at the positive electrode (anode).

To do this, pass an electric current through water and watch the hydrogen and oxygen bubbles form as the electricity breaks up the water molecule.

Remove the metal covers from two worn-out torchlight cells. You may need a hack-saw to cut the metal case. Remove the carbon rods with the brass caps from the black paste inside. Using pliers carefully loosen the brass caps. Clean the carbon rods thoroughly. Check? Now scrape off the insulation from the ends of two half meter pieces of insulated bell wire. Attach the end of each wire tightly to one end of each carbon rod with the help of tape. Light a candle. Drip some wax over the connections until they are water tight. Do not get wax on the exposed half of the rod. Remove one inch of insulation from the other end of the wires.

Now set the carbon rods in a glass of water. (If platinum electrodes are available, use them instead of carbon rods. Add as much sodium sulphate as will dissolve in a glass of cold water. (A few drops of sulphuric acid may be used or $\frac{1}{4}$ teaspoon of sodium hydroxide (lye) under *teacher supervision.*) If either is added to water, it makes the water a better conductor of electricity. Now connect the exposed ends of the wires to two or four dry cells connected in series (why series). You can test for the presence of an electrical current by bringing a compass near the

connecting wires. If the current is present, the magnetic field about the wire will be shown by deflection of the pointer of the compass.

What do you observe taking place at the carbon rods? Do bubbles form at the same rate at both rods? Do the bubbles rise at the same rate at both rods? The gas that forms in greater amounts is hydrogen, the lightest gas known. The other gas is oxygen. The two gases were in water before you separated them by passing an electric current through it.

To check more accurately the amount of hydrogen in water, fill two test tubes with the acid water. Insert them over the carbon rods and clamp in place on a ring stand so that the water does not run out and the tubes do not touch the bottom of the dish.

Insert either a carbon rod or a platinum electrode in each tube and connect the wires to the poles of your dry cells in series. After a time the gases of hydrogen and oxygen will replace the water in each tube. If you have carefully set up your demonstration, the hydrogen gas will collect twice as fast as the oxygen. Explain this. At which electrode did the hydrogen collect? (negative). The oxygen collects at the positive electrode.

The use of an electric current to break up a compound, in this case water, is called *electrolysis*. You may wish to break up some other compounds.

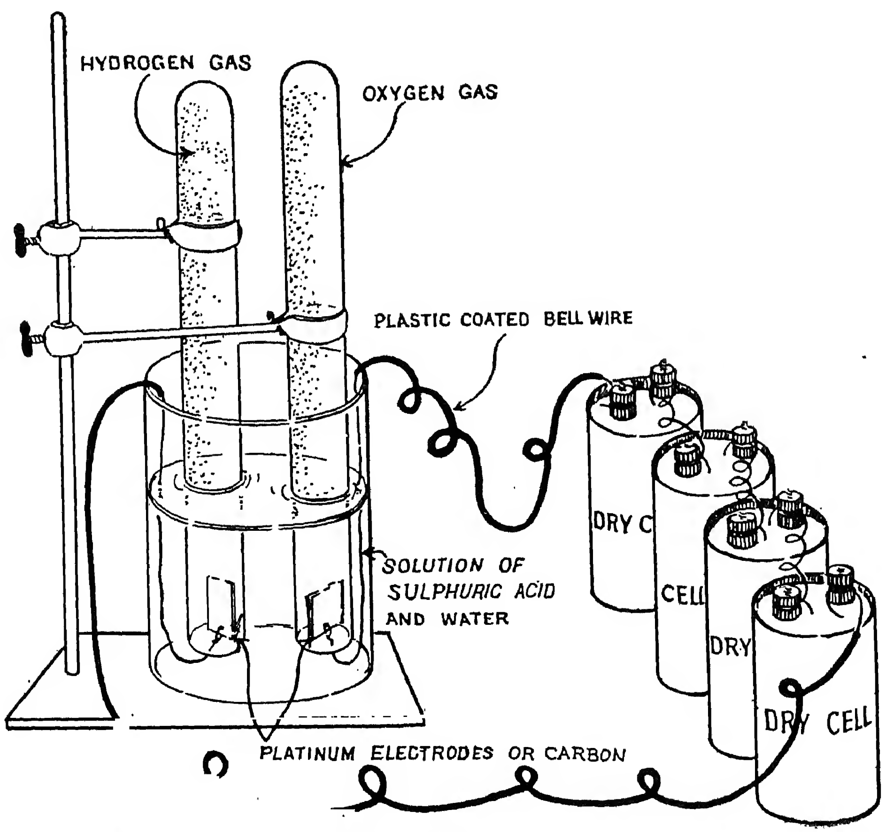


Fig. VII. 26. Electrolysis—collecting hydrogen and oxygen.

Concept 4-b, c (p. 85) : (b) During the electrolysis of a salt the metallic part collects at the cathode and the non-metallic part goes to the anode.
(c) The electrolysis of a certain metallic salt may be used to deposit the metal of that salt on another metal. This is called 'electroplating.'

Dissolve a small amount of copper sulphate crystals in a beaker of water and add a few drops of sulphuric acid. (Be careful not to spill the acid.) Why do we add the acid? Clean a strip of iron or a steel spoon and fasten the uninsulated end of a piece of bell wire to each. Connect the wire from the iron or an extra steel spoon to the negative pole (cathode) and the copper strip to the positive pole (anode). Place the two strips in the copper sulphate solution, observe what happens. What is formed on the spoon or strip of iron? This is called *electroplating*. You can observe only the copper being deposited on the iron. The chemist will explain it by saying that an 'ion' is an atom that has gained or lost electrons, so it is electrically charged. When the current is flowing through the copper sulphate solution, positively charged copper ions are attracted to the cathode where they gain electrons and become copper atoms. So you see the deposit of copper.

At the same time the copper atoms in the bar of copper lose electrons and become copper ions that pass into the copper sulphate solution, and so the process is continuous.

This same principle is used in gold and silver plating. Try to explain this process to some one who has not studied about it.

Read more about electroplating. Is it an important industry in your country?

Major Concept 5. Aluminium is separated from its oxide in an electric furnace by electrolysis.

A number of minerals can be separated from their ores by electricity. Aluminium is one of these.

Read about Charles Martin Hall (1863-1914). In 1889 at the age of 26, with his great interest in chemistry, he was able to melt some cryolite and dissolve some aluminium oxide in it. When he passed an electric current through this, the aluminium oxide was separated into its parts : the elements, aluminium and oxygen. This process is called the Hall electrolytic process, or the Hall-Heroult process because a Frenchman, Heroult, also discovered a way to separate aluminium from its ore by electricity. You will recall how you were able to separate water by electrolysis into its elements of hydrogen and oxygen. Why do you think an aluminium factory should be near a good source of electrical power?

Concept 5-a, b, c (p. 85) : (a) Aluminium oxide is prepared from its ore, bauxite, by crushing the ore and washing out the sand with water.
(b) Aluminium oxide is dissolved in molten cryolite at a temperature slightly less than 1000°C.
(c) The huge current between two graphite electrodes melts the cryolite which dissolves the aluminium oxide. By electrolysis, oxygen is separated from the ore. The molten aluminium collects at the bottom of the furnace, from where it is removed.

Find out about the ore, *bauxite*. It was named from the town of Baux in France where it was first discovered. Most of the aluminium is obtained from this ore, as it is easier, but bauxite

is not as abundant as many other ores of aluminium.

Find out if bauxite is found in India. Is there enough for all uses or does it have to be imported? Make a map of India, locating places where important metals are found.

Aluminium is one of the world's most abundant elements, but it is very expensive to extract the metal from ordinary earth. Why? Study the process of extracting aluminium from its ore. First it is mined, washed and treated chemically to form alumina. This is dissolved in a melted mineral called 'cryolite' or 'ice stone' which was once a principal source of aluminium. This mineral is melted at a very high temperature, around 1000°C or 1800°F.

This is done in a carbon-lined container. The carbon lining is attached to the negative terminal of a source of direct current, while some carbon rods that dip down into the solution are connected to the positive terminal. As electricity flows through the container, the aluminium falls to the bottom. Can you tell why? It is then drawn off in moulds and hardened into ingots of pure metal. These can then be shipped all over the world to where aluminium is needed.

One molecule of alumina is made up of two atoms of aluminium and three atoms of oxygen. Write this formula. Does it look like this $Al_2 O_3$?

The oxygen from this separation process unites with the carbon in the anodes to form carbon dioxide gas which escapes in the crust of cryolites.

Find uses of aluminium in your daily life. Make a list of its characteristics which make it so useful to man.

Are we in danger of using up the world's supply of aluminium?

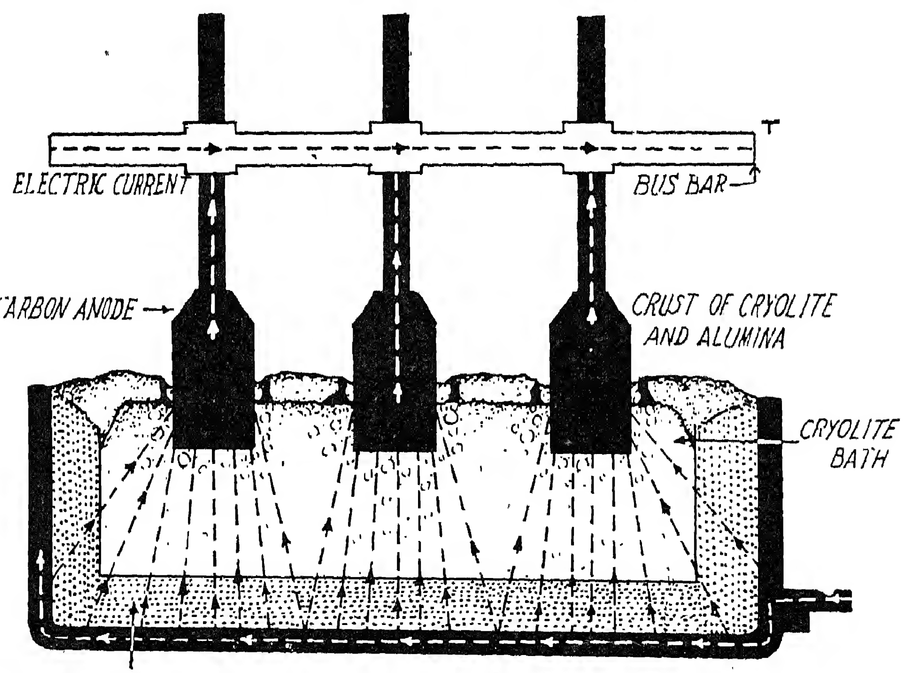


Fig. VII.27. Hall's process for extracting aluminium.

UNIT VIII Living Things

CLASS VIII

Major Concept 1. The unit of life is a cell.

Concept 1-a (p. 87): A cell is microscopic in size.

Take an onion bulb and cut it into halves along the length. Take out one of the fleshy leaves and with your fingers peel the outer skin. Mount a small piece of this skin in a drop of water on a microscope slide. Place a cover glass on it and observe under a microscope. Observe how the *cells* are arranged and how many cells there are in that tiny bit of tissue. Make out each individual cell and draw sketches. Try to find out the contents inside each cell.

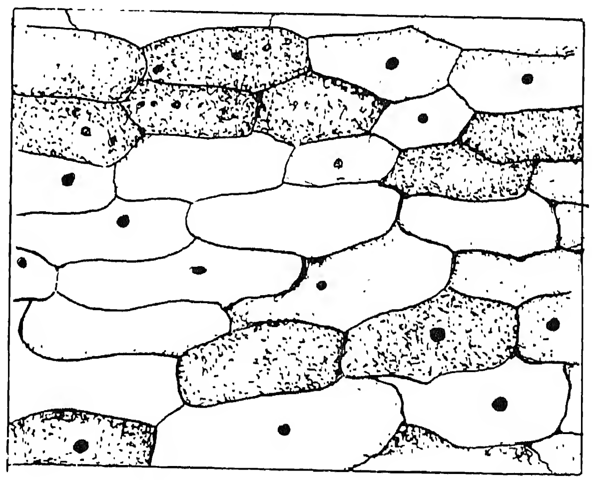


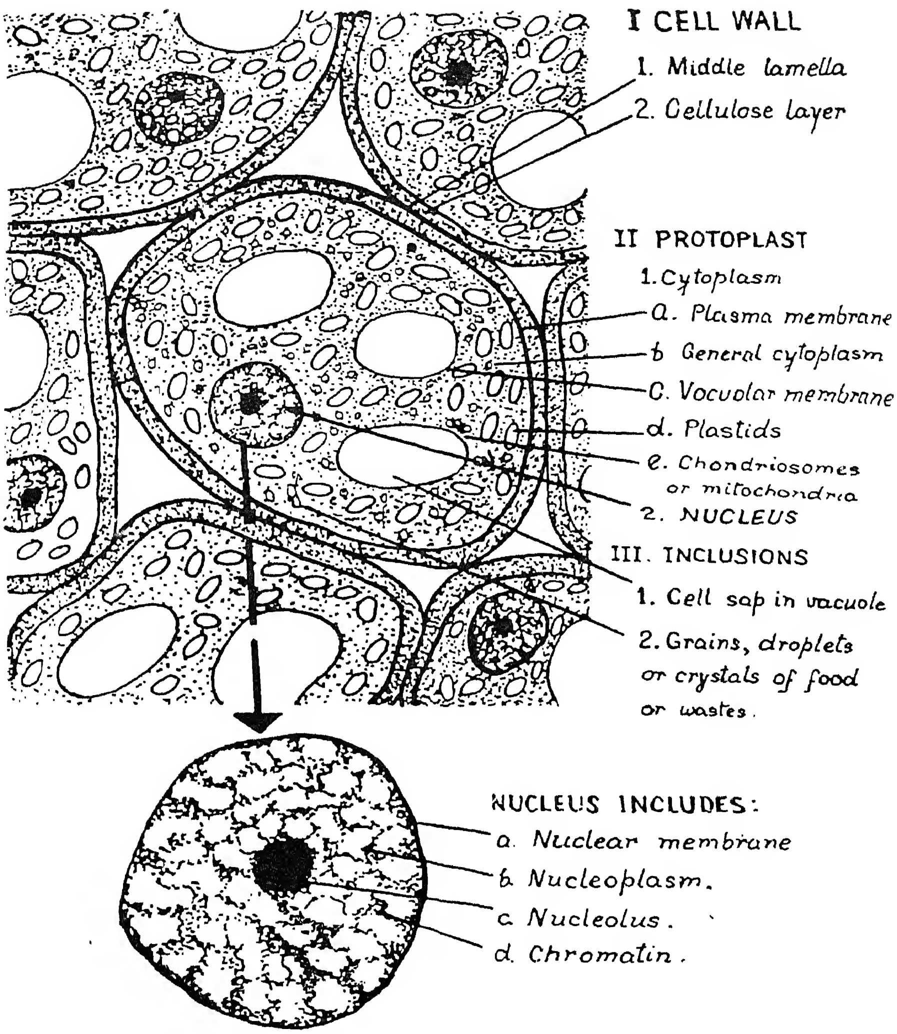
Fig. VIII.1. Cells in onion.

Concept 1-b (p. 87): The major part of the cell is protoplasm, which consists of a nucleus and cytoplasm.

1. Observe the cells in onion skin under a higher power. Look at the *nucleus* and observe it closely. What is the shape of the nucleus?

2. Mount the hairs found on the stamens of *Tradescantia* flower. Observe the nucleus.

What is the jelly-like substance surrounding the nucleus? Make out the different parts: cell wall, cytoplasm and nucleus. The *cytoplasm* together with the nucleus is called *protoplasm*.



Men wondered about cells during early Greek times, but only after the invention of the microscope did knowledge about the cell become more accurate. Robert Hooke, an English scientist in 1665, saw that cells from fresh vegetable material had walls and were filled with 'juices'. In Fig. VIII.2, parts of the cell are named to give some appreciation of how much is now known about this most complicated structure, the cell.

It will be noted that the contents of any particular cell are referred to as the *protoplast*, that the protoplasm is commonly divided into the nucleus and the cytoplasm. Cells possess characteristics that distinguish living from non-living matter; they take in food and transform it into cellular material; they give off wastes; they reproduce.

Fig. VIII.2. Plant cells showing nucleus and cytoplasm (Hairs of the stamens of *Tradescantia*)

3. Mount a few filaments of *Spirogyra*, an alga, on a slide and examine one of its cells under the microscope. Make out the central nucleus, the strands of cytoplasm connecting the nucleus to the protoplasm next to the wall. You can also see bands of green structures which are called chloroplasts which contain chlorophyls.

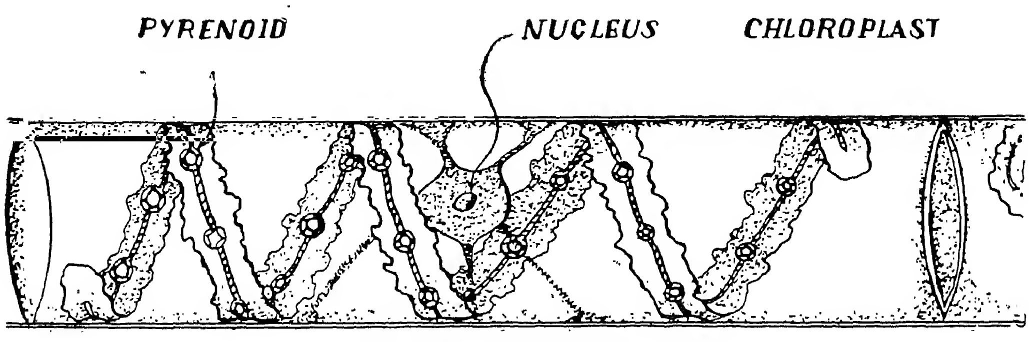


Fig. VIII. 3. 'Spirogyra' —A Cell

Concept 1-c (**p. 87**) **:** Some living things are unicellular and others are multicellular.

Visit a pond or a lake and see the types of vegetation there. In a rain-water pond the water often has a greenish tinge. Collect this water in a specimen tube or a bottle. Collect enough to fill half the capacity of the tube or bottle. In the lake or tank look at the shore vegetation. Collect some scum attached to stems of water plants. This can be done by taking a few stems in one hand and squeezing the scum into a dish. The contents of the dish can be poured into specimen tubes. Bring the tubes to the school and keep the tubes open by removing the corks. Examine a drop from each bottle at a time under a microscope. To do this, take a drop of the water by means of a pipette and place it on a glass slide, then cover the drop with a cover glass.

What do you see in this drop of water? Do you see plenty of green plants and tiny animals? Make drawings of as many as possible and try to identify them. You may find some whose bodies consist of single cells and some who have many cells. These are unicellular and multicellular organisms. Do you find some moving and others stationary?

Major Concept 2. Many micro-organisms are unicellular.

Concept 2-a (**p. 88**) **:** Bacteria and yeast are unicellular plants.

1. To show that bacteria are *unicellular* plants, get a collection of bacteria and examine them in a tiny drop under the microscope using the high power. Bacteria may be found in pond water, scum of any stagnant water, cow's milk or decaying food. Bacteria can be secured by soaking bean seeds in a little water in an open container for several days.

Take great caution while handling bacteria. Wash your hands with soap and water every time you handle the material. Explain why you do this.

Place a drop of the material in a drop of water on a glass slide and add a tiny drop of methylene blue or eosin or even red ink, to give it colour. Gently lower a cover slip over the liquid. Examine under the high power of the miscroscope. Focus carefully and adjust the light. Observe the shape of the bacteria. Some are round (coccus), some rod-shaped (bacillus) and some are spiral (spirillum). Some may even have a whip-like flagellum. Note that they are all unicellular.

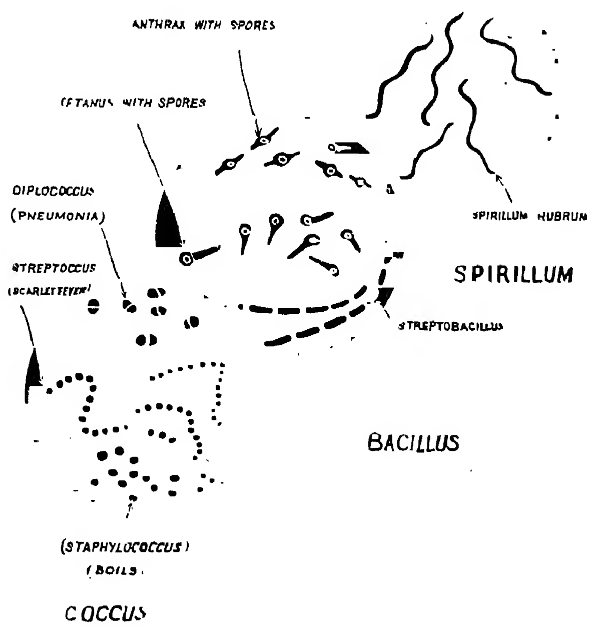


Fig. VIII. 4. Bacteria—typical examples.

2. To show that yeast is unicellular take a drop of yeast culture on a slide and place a cover glass over it. Bakery yeast can be purchased or can be made by exposing crushed grapes. Watch the yeast under both the low and high power. Note that some cells are dividing by budding.

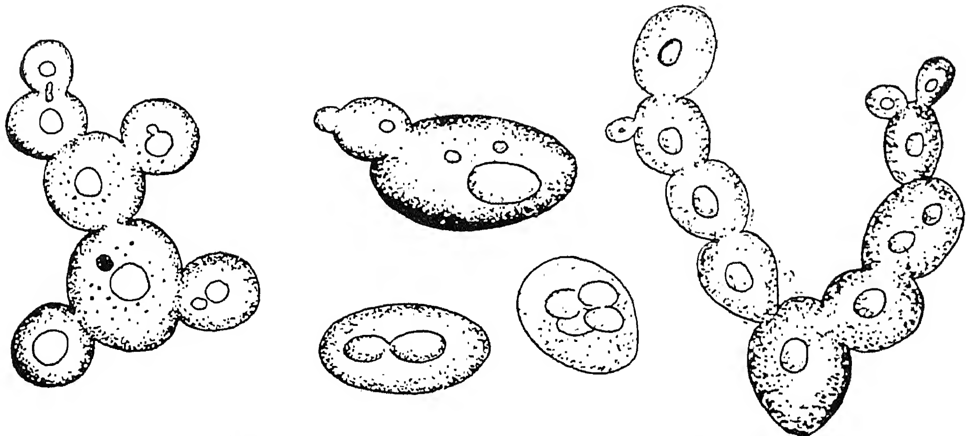


Fig. VIII.5. Yeast plant reproducing by budding.

Yeasts are unicellular. Shake the glass slide and note the young cells separate from the larger cells.

Concept 2-b (p. 88): *Amoeba* and *Paramecium* are unicellular animals.

Obtain a collection of *Amoeba* and *Paramecia* from a fresh water pond. Take samples from the greenish scum floating at the top or from the bottom at the edge of the pond. Fill each tube or bottle to three quarters full. On return to the school, remove the covers. This is necessary to let in fresh air for the organisms to respire. The

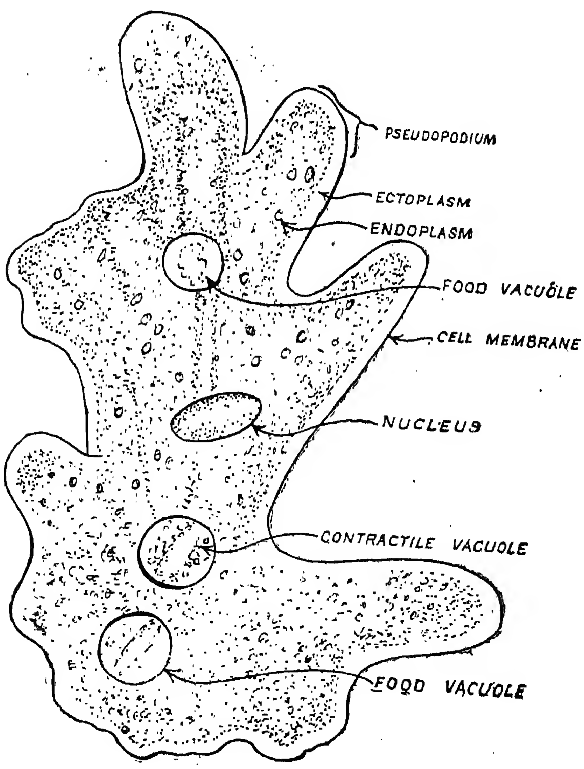


Fig. VIII.6. Amoeba.

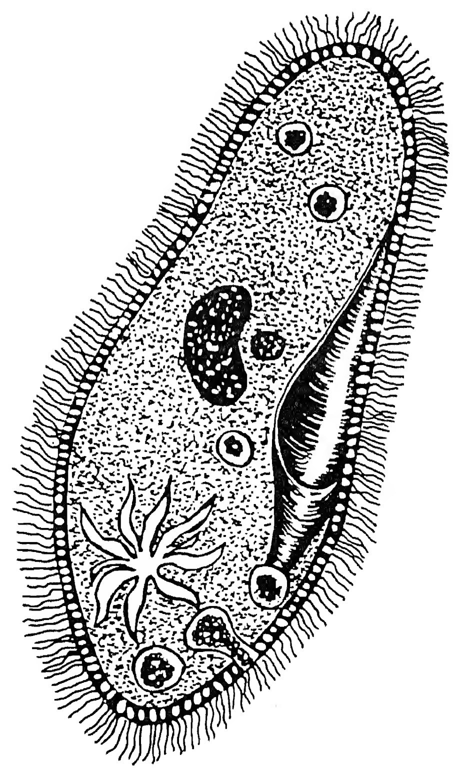


Fig. VIII.7. Paramecium.

sample collected will be a good culture of protozoans.

Place some dry leaves in a glass jar. Add tap water that has been standing uncovered for sometime. Cover the jar and set aside in a well lighted part of the room but not in direct sunlight. Observe one drop from this culture every day. *Amoeba* and *Paramecia* appear in a day or two. Good specimens of *Amoeba* or *Paramecia* can be obtained from the bottom or sides of the container. Or collect a small bit of plant material along with the drop. Observe the shape and structure of *Amoeba* and *Paramecia*. Note that they are unicellular. Draw sketches.

Concept 2-c (p. 88) : Unicellular micro-organisms reproduce by cell division.

To show that micro-organisms reproduce by cell division, examine a drop of yeast culture in a hang-drop culture. Take a glass slide and stick to this a ring of glass or bakelite, with the help of vaseline. Smear the rim of the ring also with vaseline. Place a drop of yeast culture on a cover slip. Quickly invert it over the ring and gently press. The drop will be hanging in the cavity of the ring on the underside of the cover glass. Examine the water under a microscope. Note the yeast cells. Note that they increase in number by some cells budding into two.

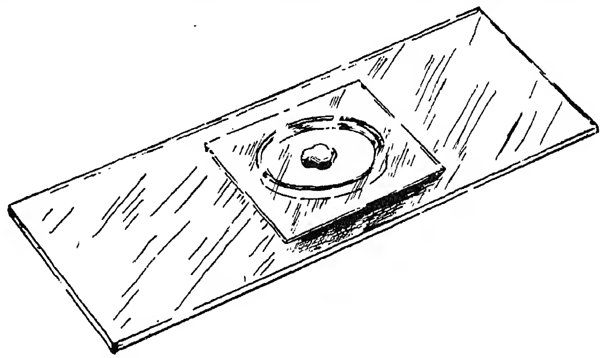


Fig. VIII.8. Hang-drop culture to study cell division.

Concept 2-d (p. 88) : Green micro-organisms make their own food.

All green plants produce oxygen during photosynthesis and so do algae. Collect algae (unicellular or filamentous) in a test tube, by filling it with water in which the algae were growing. Half fill a wide mouthed jar (battery jar or a finger bowl) with the same water. Close the test tube with your thumb and invert it quickly without allowing any air bubble to enter the tube. Now place the rim of the test tube below the level of water in the large jar and remove the thumb. The test tube can be fixed to a clamp on a ring stand. Set this apparatus in strong light (not direct sunlight) and leave it for some time. Note that tiny bubbles collect at the upper end of the inverted tube. When enough gas has collected remove the tube, closing the open end by a thumb or cardboard. Insert a glowing splinter into the gas at the top of the tube. What happens to the glowing splinter? Does it burst into flame? What is the gas that makes the splinter burst into flame?

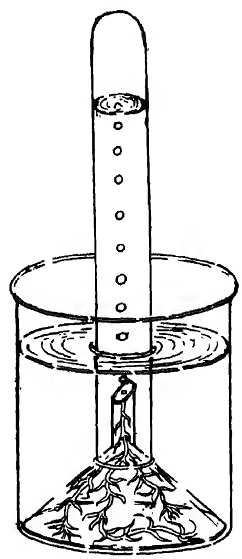


Fig. VIII.9. Green plants evolve oxygen during photosynthesis.

Concept 2-e (p 88): Many micro-organisms exist on dead organic matter. These are called 'saprophytes.'

Observe any decaying fruit or vegetable during moist weather. You may find them covered with white cob-web like threads. Old shoes in damp weather also get similarly covered. Examine a piece of this growth in a drop of water under the microscope. How do these plants look? Are they green? If not green, from where do they get their food? These plants grow on dead fruits, vegetables or leather. Can they make their own food? They are *saprophytes*.

Concept 2-f g (p. 88): (f) Many micro-orgamisms live on other living organisms (hosts). These are called 'parasites.'
(g) Parasitic micro-organisms cause disease in hosts.

During the wet season, observe the underside of leaves of *Amaranthus* (a green vegetable) or leaves of the weed *Cleome*, or *Gynandropsis*. You may find here and there white patches. Scrape a little of this, or better still cut a section with a razor. of the leaf passing through the white patch Examine the section under a microscope. You may find colourless (non-green) thread-like structures, resembling a mould. They grow on a living *host*. Where do they get food from? What are these called? (*parasites*.)

Find out about some of the parasites which cause human and plant diseases.

Major Concept 3. Man uses micro-organisms for various purposes.

Concept 3-a (p 88): Yeast is used in making bread, wine, biscuits and *jalebi*.

To know that yeast is used in making bread, biscuits (rolls) and *jalebi*, visit a bakery or a sweet-maker's shop. See how they make their dough and why they add yeast to the dough. What makes bread rise? How does it become so soft and full of holes, looking almost like a sponge? Collect some yeast from a bakery and examine it under a microscope.

If a brewery is nearby, visit it and observe how the fruit juice is allowed to ferment. What do they add? Leave some fruit juice in a glass and set it aside (apple juice and grape juice). After 6-12 hours examine a drop of the juice which has turned sour. Draw what you see under a microscope. These are yeast plants.

Concept 3-b (p 88): One type of bacteria changes milk into curd.

In making *curds* at home, what is added to the milk as a starter? Examine a drop of curd under the microscope. What do you observe?

Concept 3-c (p. 88) : Certain types of bacteria enrich the soil.

Make some 'compost' in a bottle : Take some dry leaves and powder them. Put some of the powder in a bottle and cover it with a layer of ash. Just moisten it and then repeat this forming alternate layers of leaf powder, ash and moisture.

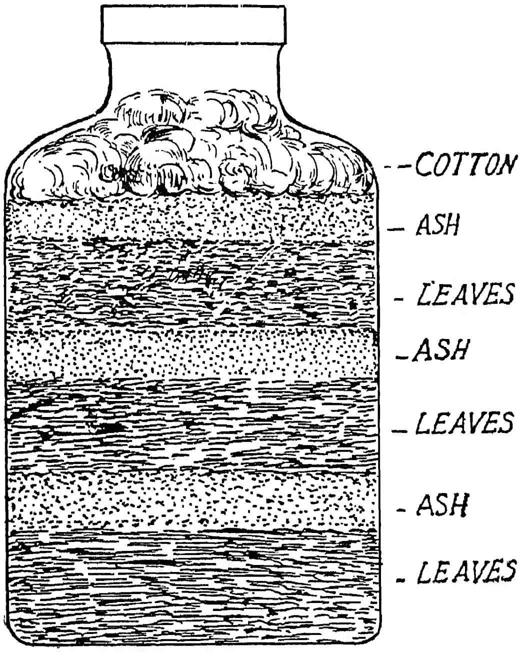


Fig. VIII. 10. Compost bottle.

Plug the bottle with cotton wool and set aside. Examine it from time to time. Do you find the bottle getting warmer? Why? Do you see the leaf powder changing its colour to darker shade and finally to black almost like compost? What makes the leaf become dark? What happens to all the dry leaves and dead plant and animal remains that fall on the ground?

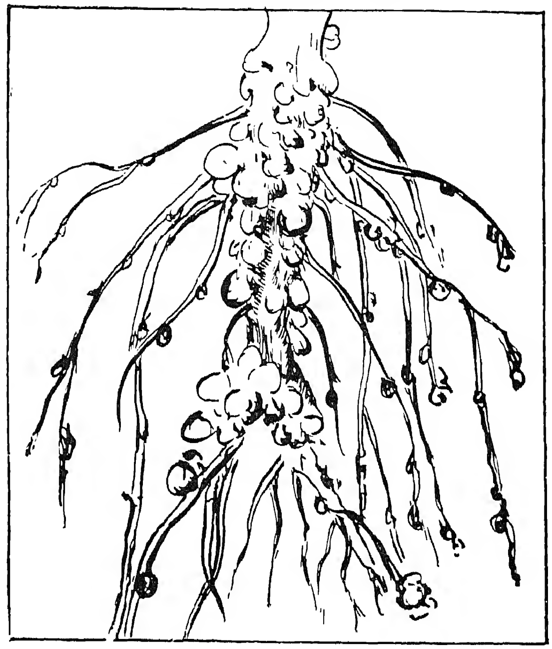


Fig. VIII.11. Root nodules containing nitrogen fixing bacteria.

Dig out carefully a leguminous plant like a gram or pea plant. (If the soil is dry pour some water on it and dig out the roots with the wet soil.) Wash the soil away with water and examine the roots. Do you find spherical structures on the bare roots? These are called *nodules.* Crush one of these nodules on a glass slide. Add a drop of water, place a cover glass on it and examine under the microscope. What do you find inside? (nitrogen-fixing bacteria). How are these bacteria helpful to the soil?

Major Concept 4. Multi-cellular organisms have complex, organised structures of several kinds of cells.

Concept 4-a, b (p. 88) : (a) Every cell carries on certain vital processes : namely, assimilation of food, growth, respiration, excretion and reaction to stimuli.
(b) Every cell also carries on certain specialized functions.

Take out a small plant with leaves, branches and roots. Is this unicellular or multicellular? In multicellular plants some cells perform one function and others perform other functions.

Take a section of a leaf and examine it under the microscope.

Take a section of the stem and examine it under the microscope.

Take a section of the root and examine.

You will notice that cells have differen structures suited to perform separate functions.

Major Concept 5. Heredity is the transmission of the character of parents to their offspring.

Concept 5-a, b (p. 88): (a) Each individual starts as a fertilized egg cell.
(b) The male parent furnishes the sperm and the female parent furnishes the egg.

To help understand how parental characteristics are found in the young, examine a flower bud just about to open. Take out the sepals and petals, then take a few anthers on a slide and crush them gently with a cover slip. Add a little carmine (stain) or eosin and examine under a microscope. How many darkly stained structures do you find inside? For flower parts, refer to Unit IX, Class VI, Concept 2.

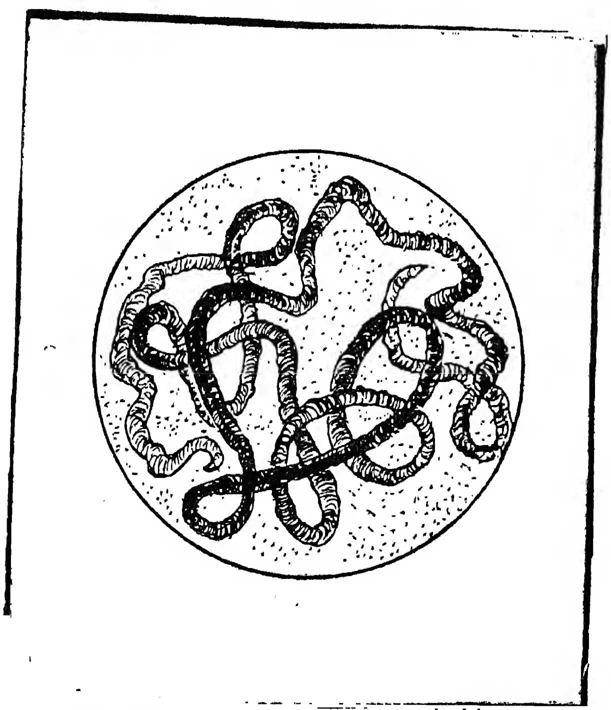


Fig. VIII.12 a. Chromatin in a tangled thread, the spireme.

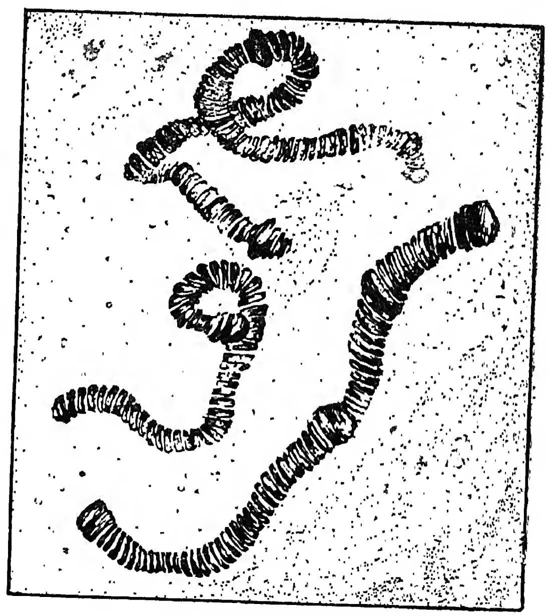


Fig. VIII.12 b. Chromosomes.

What is their role in fertilization? Find out about chromosomes.

Cut a pistil lengthwise or crosswise and observe the ovules. What role do these structures play? What happens to the ovule after fertilization? An ovule becomes a seed after fertilization.

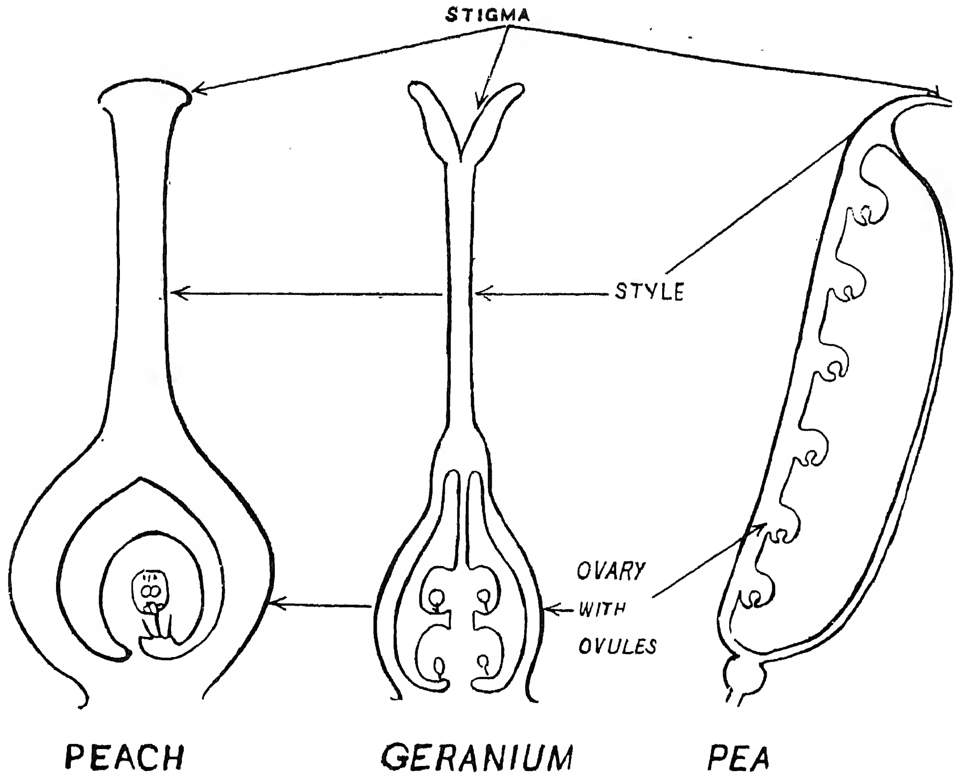
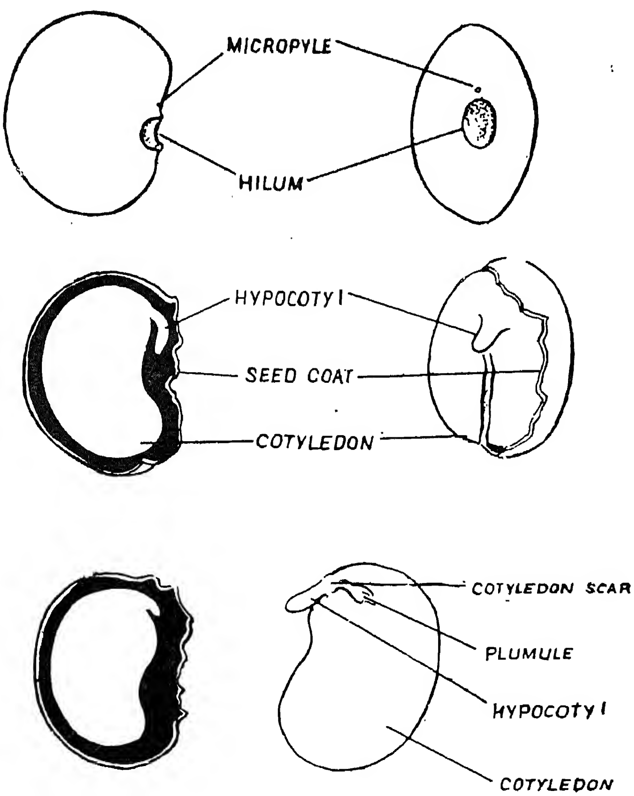


Fig. VIII.13. Different pistils showing ovaries with ovules.



Which sex cell does the pollen grain contribute and which sex cell does the ovule contribute?

Dissect a soaked bean seed. Separate the cotyledons from the embryo. How was the embryo formed? Is it multicellular now? At the beginning of its development did it arise from a single cell? Can an ovule develop into a seed if no fertilization takes place?

Fig. VIII.14. Bean seed and its parts.

Concept 5-c d, (p. 88) : (c) The union of the sperm and the egg results in the fertilized egg.
(d) The characters of the parents are passed on to the offspring through these sex cells.

1. Observe a cat with its litter of kittens or a bitch with a litter of pups. Why is it that a cat always begets a cat and a dog, a dog? If you sow bean seeds, do you get bean seedlings or any other seedlings? What does this show? Why is the offspring like its parents? Has anyone ever heard of a dog having kittens?

2. In the previous activity we found that to produce a seed, the anther contributed the sperm cell and the ovule, the egg cell. If this were so, how do you account for the characteristics of the offspring? Will it resemble its father or mother or will it have some characteristics of each parent?

3. In the class, if there are two brothers or two sisters or a brother and a sister, see their similarities in features and other characteristics. Note also the differences. If available ask them to bring photographs of their parents and compare. Make a study of as many children as possible with their sisters or brothers and parents. Note that some children resemble their father most and others their mother most.

4. Plan a field trip in season to collect eggs of animals. Also study flowers and trees and as they begin to blossom. Establish the similarity between sexual reproduction in plants and animals. (Fertilization consists of the union of an egg nucleus and a sperm nucleus in both.)

5. Refer to Concept 2-a (3), for collecting green scum on a pond or tank. Examine the thread like filaments from this under a microscope. *Spirogyra,* a common filamentous algae has green chloroplasts arranged in a spiral which you can easily recognize under the microscope.

Look at several filaments to see if you can find any arranged side by side as shown in Fig. VIII.15 . If you do not find any in the fresh material, keep the algae in a jar for a few days and examine again. You may be lucky enough to find cells conjugating. (reproducing sexually).

All the green cells are sex-cells (gametes). When conjugation occurs, a small *conjugation tube* is formed between two opposite cells. Then the contents of one of the cells moves into the other one and fuses with its contents. A *zygote* is formed by this fusion. This zygote corresponds to the *fertilized egg cell* in higher plants and animals in the process of reproduction . See Fig. VIII.15 for the various stages.

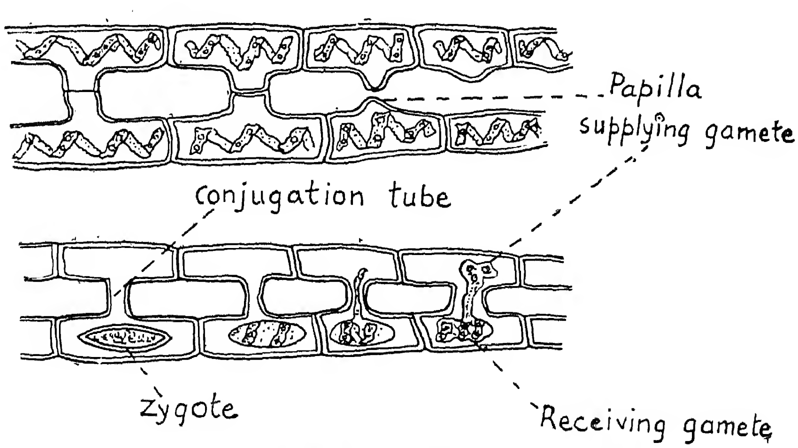


Fig. VIII.15. Spirogyra reproducing (conjugating).

Major Concept 6. Inherited characters are transmitted according to definite biological laws which were first formulated by Gregor Mendel.

Concept 6-a (p. 89): Different individuals have different characters. In Mendel's peas there were variations in the size of the plants, smoothness of seeds, and colour of seed coats.
There are also variations in animals, for example in humans, the colour of hair, straight or curly hair, skin pigmentation, height; in guinea pigs—the colour of coat, length of fur, spotted or solid colour; in dogs—head carriage, head length, hair length, foot length.

Observe children of the same parents. Note the differences in them. Observe the pups of one litter. Do all look alike? Why do they vary? Examine a field of vegetables. Compare the fruits of different plants. Note variations in them.

Concept 6-b (p. 89): When individuals with different characters were crossed, the hybrid offspring resembled one parent. (For example, all the peas were tall, or all seeds were smooth, or all had yellow seed coats.) This Mendel called the 'Law of Dominance.' The characters which did not show in the first generation were called 'recessives.'

Examine a chart showing the crossing between individuals which vary in their characteristics; *e.g.*, tall pea plant and dwarf pea plat, white guinea pigs, and black guinea pigs. What is the characteristic of the first generation? All individuals have the characteristics of one of the parents. What is this called? (Dominant character.) The character of the other parent is not seen. What is this called? (Recessive character.)

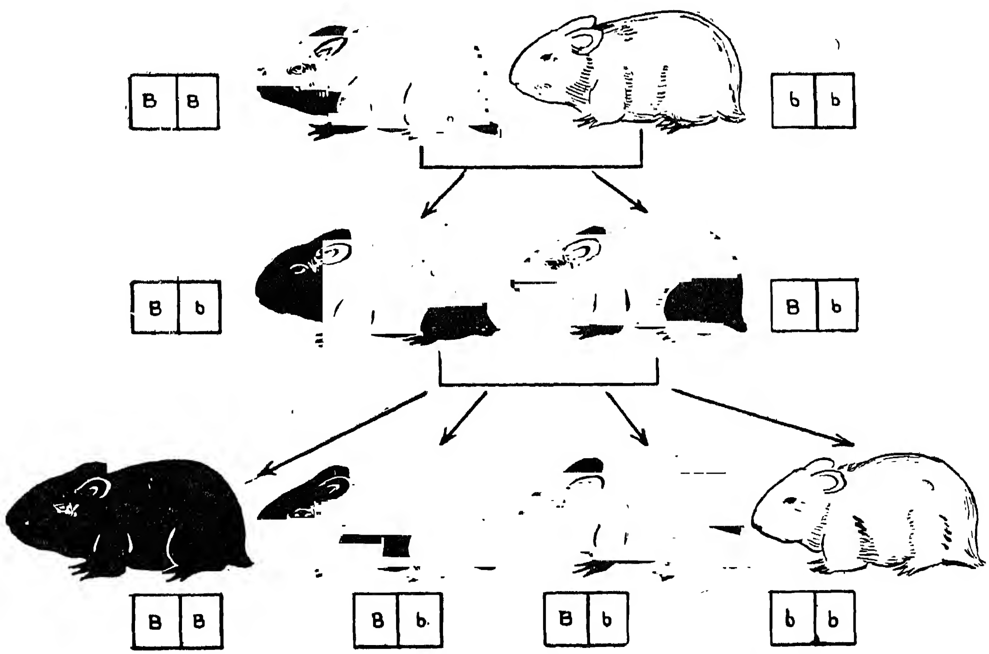


Fig. VIII.16. Cross between pure white and black guinea pigs.

Certain human characteristics are dominant and others are recessive. Watch for these dominant characters among your classmates and note which of their parents has this trait:

(1) Dark skin colour X Fair skin colour.
(2) Curly hair X Straight hair.
(3) Dark hair X Light hair.
(4) Free earlobes X Attached earlobes.

The tall pea plant will have some factor that produces tallness. Let us say this is TT (factors come in pairs). The dwarf plants have tt (they do not express themselves). Now suppose you try what is called a chi-square.

	T	T
t	1	2
t	3	4

Fig. VIII.17. Chi-square (1).

Result of:

TT X tt (i.e. Tall X Dwarf plant): The gametes or sex cells of these plants come together when crossed. (The sex cells have only one factor.) What will be the combination of genes in the four squares 1, 2, 3 and 4? You are told that T is dominant. Then what will be the characteristic of the four offsprings in the square?

	T	t
T		
t		

Fig. VIII.18. Chi-square (2).

Try a second chi-square in which these hybrids of first generation are crossed with each other. What will be the nature of the four offsprings in the second generation? How many will be tall and how many dwarf?

Concept 6-c (p. 89): When the hybrid individuals were crossed among themselves, the offspring showed the dominant and recessive characters in the ratio of 3:1. This is known as the law of segregation.

Among the people of the white race some have brown eyes and some blue eyes. Brown is dominant and blue is recessive. Suppose, John has brown eyes. He got the factor brown from his father and blue from his mother. He marries Ann who also has brown eyes. She got the factor brown from her father and blue from her mother. If John and Ann have a child what colour will the child's eyes be? Will it be brown or blue? What are the different possibilities?

To find out, do this. Cut a small square piece of brown paper and small square piece of blue paper. Let these be the dominant and recessive traits of the eye colour of the father. Cut two

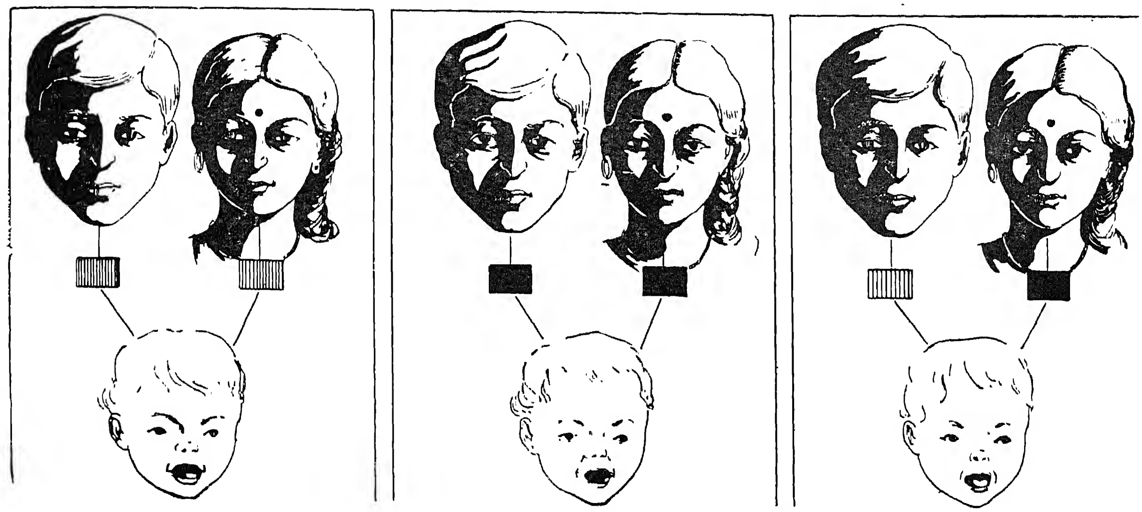
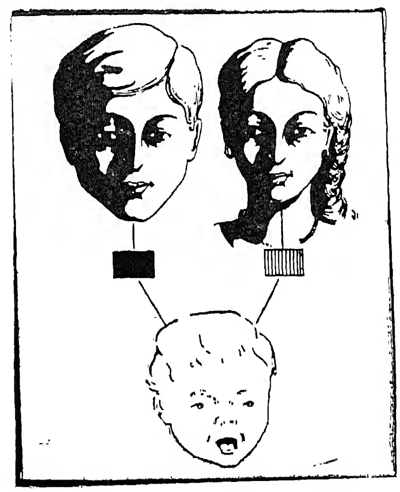


Fig. VIII.19. Dominant and recessive traits.



similar squares of brown and blue for the mother's eye colour traits. Now pick one of father's and one of mother's and write down. It might be one blue and one brown. What colour eye will the child have? Try all possible combinations of the square pieces and write them down. What will be the colour of the child's eyes in each case? Look at the figure. Did you get the four combinations as indicated there?

Concept 6-d (p. 89): The different characteristics such as tallness and shortness or smoothness and wrinkledness are inherited independently. This, Mendel called the 'Law of Independent Assortment.'

To find out more about characteristics that are inherited independently, work out some examples.

Characteristics of the pea plants are many. One contrasting pair is round X wrinkled seed (RR X rr). Another is yellow seeds X white seeds (YY×yy). Round and yellow seeds are dominant traits. Suppose we cross a round yellow seeded variety with a wrinkled and white seeded variety. What will be the nature of the hybrid? Fill up the squares and find out.

Now suppose two of the hybrids are crossed. What are the combinations possible? Do these two pairs of traits sort out independently? Try to fill up this chi-square and find out.

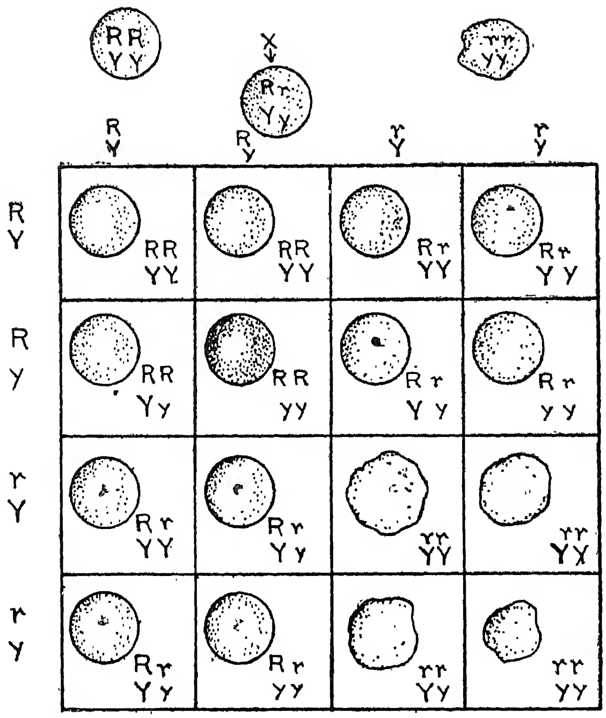


Fig. VIII.20. Trait inheritance.

Major Concept 7. Cross-breeding may be used to improve the quality of animals; offspring with undesirable qualities may be rejected.

Concept 7-a (**p. 89**) **:** They may be stronger, or run faster.

To learn about the quality of breeding animals examine some pictures of good breeds of horses. Observe how their limbs are formed and how they are fitted to run faster. Learn about the pedigree of parents from which these breeds are obtained.

'Thoroughbred' is a racing horse bred by crossing English running mares with Arab stallions.

Concept 7-b,c (**p. 89**) **:** (b) They may yield more milk, eggs, wool or meat.
(c) They may look better.

Visit an agricultural farm or Research Station. Observe how some poultry are bred for good eggs, some sheep are bred for meat, and cows are bred for more milk. All animals or plants bred for desirable characteristics are better in those particular ways.

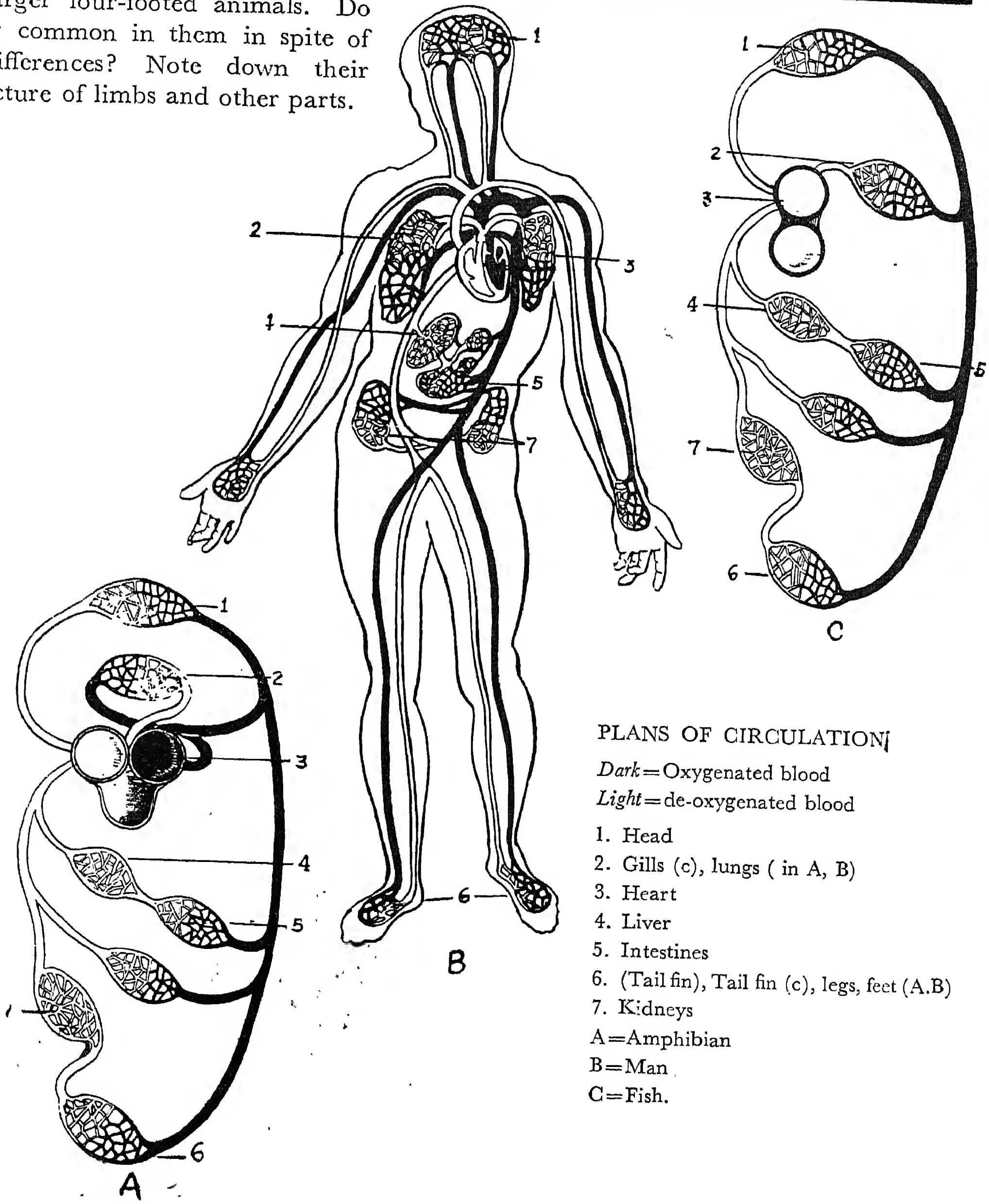
Concept 7-d (**p. 89**) **:** They may be resistant to diseases or climates.

Observe the work done in breeding plants to resist diseases and to withstand adverse conditions of climate.

Major Concept 8. All the present day life on earth is believed to have developed from a common ancestry.

Concept 8-a,b (**p. 90**) **:** (a) All living things are alike in many respects.
(b) Striking similarities of structures seen in animals cannot be accidental:
(i) Skeletons and muscles of vertebrates show similar corresponding parts.
(ii) The digestive organs of vertebrates show similar structure and functions.
(iii) The circulatory and respiratory organs show similar structure and functions.

Observe the larger four-footed animals. Do you see something common in them in spite of their outward differences? Note down their similarities in structure of limbs and other parts.



PLANS OF CIRCULATION

Dark=Oxygenated blood
Light=de-oxygenated blood

1. Head
2. Gills (c), lungs (in A, B)
3. Heart
4. Liver
5. Intestines
6. (Tail fin), Tail fin (c), legs, feet (A.B)
7. Kidneys

A=Amphibian
B=Man
C=Fish.

Fig. VIII. 21. Comparing circulatory systems.

Examine the skull of a dog, an ox and that of a man, if they are available in the school or in a museum. Note the main similarities. Similarly compare pictures of the digestive organs of different animals; also their heart, lungs and circulatory systems.

Study diagrams of heart, lung and circulatory systems of different animals (Fig. VIII. 21).

Concept 8. c (p. 90) : Fossil records of past life show that living things have become increasingly varied and specialized with the passage of time.

(i) Early fossils are mostly gastropods, brachiopods or trilobites.

(ii) Fishes were the first vertebrate fossils.

(iii) Reptiles, birds and mammals appear much later.

(iv) The modern one-toed horse evolved from an ancient four-toed animal about the size of a fox, in the course of an estimated period of fifty million years.

Fossils which are typical of particular period or epoch of earth's history are useful to the scientist who studies the history of the earth. When he finds one of these fossils in a layer of rock anywhere in the world, it tells him the relative age of the rock.

The ideal index fossil is one that existed a very short time in earth's history and was widely distributed over the earth. An animal called the *trilobite* is often used as an *index fossil*. These were scorpion-like animals that lived during Palaeozoic times (Fig. VIII. 23). At the end of this period there were no more trilobites. Fossil trilobites are plentiful and are world wide.

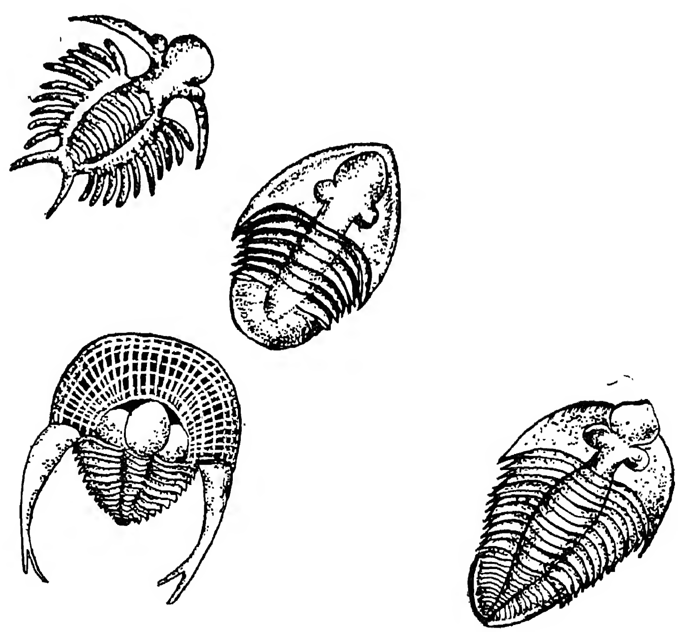


Fig. VIII.22. Trilobites.

Find out if there are any fossil deposits near your school. Study Fig. VIII. 23.

See any charts or a demonstration board in a museum or a college displaying the fossils of forms of living things through geological time. Animals were simple in earlier ages and more complicated in later years. See any chart depict-

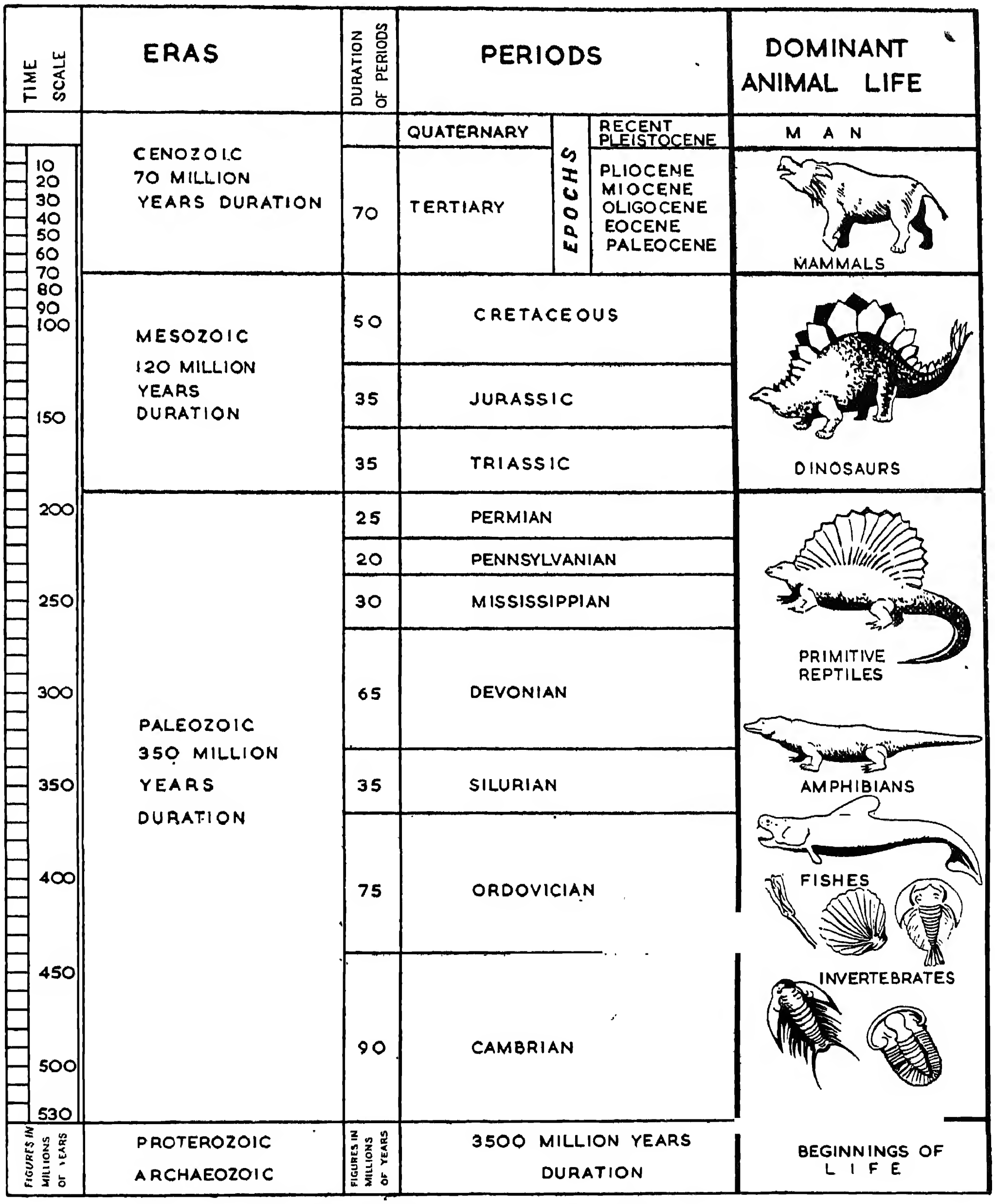


Fig. VIII.23. Geology time chart.

ing in pictures the evolution of a horse. Examine the toes and note down what you see.

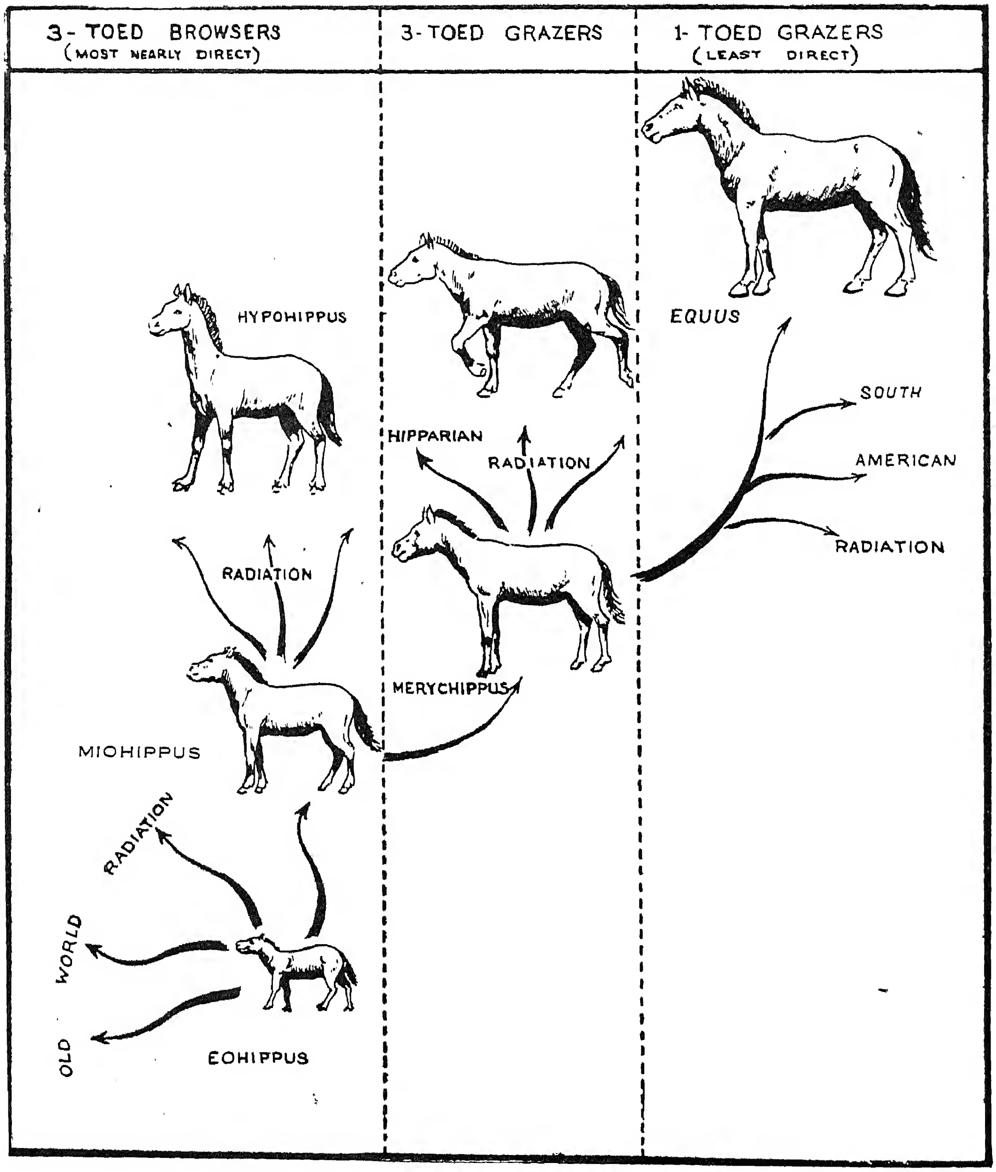


Fig. VIII.24. History of a horse.

Miohippus was only one product from *Eohippus* (no bigger than a fox). It was still 3-toed and browsed on trees and shrubs. From *Miohippus* many forms came, one of them *Merychippus*, became a grazer, a grass eater. This led to the one-toed *Equus*. The history of horse not only demonstrates that evolution is a fact but how it has occurred.

Concept 8-e (p. 90) : Darwin accounted for evolution :

(i) Each kind of living thing (species) produces many more offspring than can possibly survive.
(ii) There is a variation among the offspring.
(iii) Some individuals are better fitted to survive than others.
(iv) Natural selection follows. Those best fitted to survive become parents of future generations.

1. Examine the litter of a pig. Count the number of piglets that the mother pig suckles. In the case of a cow or a horse see how many calves or colts the cow or horse has? Imagine that all the piglets have grown big and in their turn given birth to many piglets each. If nothing happens to them what will be the population of pigs in a few years? Will it far exceed that of cows and horses? Why is it that we do not find an over-population of pigs?

2. Stand under a raintree (*Enterolobium saman*) bearing many pods. Examine a pod that may have fallen on the ground. How many seeds are there in that pod? Estimate roughly the number of pods on the tree. These are formed during one flowering season. Imagine all seeds that are formed every season to sprout into so many of these raintrees. You may have thousands of raintrees. There will be no place for other trees or even for all of the raintree seedlings to grow up healthy. But does every seed sprout? What happens to the majority of them ?

3. Examine a litter of pups growing. All are offspring of the same mother born at the same time. Some are stronger and others are weak. Some have different coloured coats. What does this show?

In that same litter some pups survive and others do not. Sow a number of seeds of a plant and see how many germinate and out of the seedlings, how many grow into full sized plants?

Which of them were best fitted to survive? Those that survive are the strongest. These in turn grow up and give birth to young ones in their turn.

UNIT IX

Plant Life

CLASS VI

Major Concept 1. Common plants reproduce by seeds.

Concept 1-a (p. 96): Plants have flowers which develop into fruits and seeds.

Find some common plants with flowers, such as bean, pea, tomato and gourds. Collect specimens of flowers in different stages of maturity, from newly opened buds to those with the petals dropped off. Observe the structure left behind in the wilted flowers. Study the illustration and locate the various flower parts. Compare it with your real flower.

Cut the *ovary* open and note the small structures (ovules) inside.

Pick out several pods of peas, beans or of any leguminous plant. Some are filled out and others are not. Open the two kinds of pods and compare the seeds of the first kind with those of the second. The shrunken seeds are those ovules which have not developed because they are not fertilized.

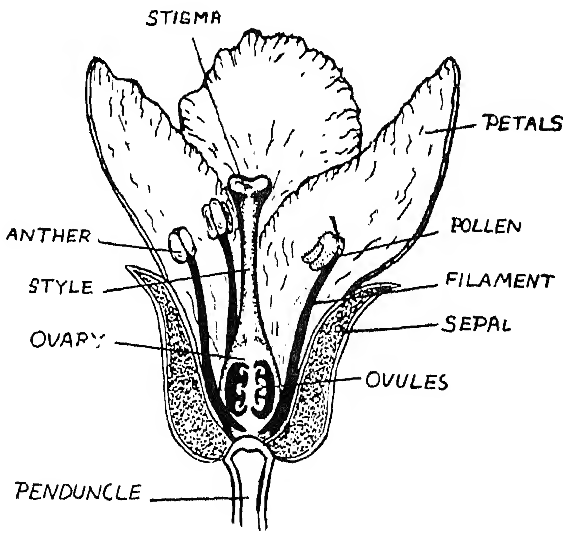


Fig. IX.1. Diagram of a flower.

Concept 1-b (p. 96): Seeds contain tiny dormant plants. They can remain dormant for many seasons.

Collect different kinds of seeds from a nursery, your own home, or school garden or from the market, such as beans, peas, pulses, paddy, maize and mustard.

Soak some seeds of each variety (such as bean and maize) separately in water for 12 hours in a shallow tray. You will find the seeds swollen. carefully peel the skins of one of each kind with a needle and examine the tiny structure between the fleshy parts. The fleshy parts are the *cotyledons* and the tiny tender structure that lies between them is the *embryo*.

Get seeds of castor or mustard and keep them in moist sawdust or in a germination box for a few days. Keep the sawdust moist. See whether the seeds germinate or not.

Fig. IX.2 shows a simple way to germinate seeds. Spread a wet cloth over a plate placed on a cardboard box. Let the end of the cloth dip in a glass or bottle of water as shown in the

figure. Any empty jam bottle will serve the purpose. The cloth dipping in water will keep it moist. Place a few soaked seeds on the cloth and fold the cloth over the seeds. After a day or two unfold the cloth and observe.

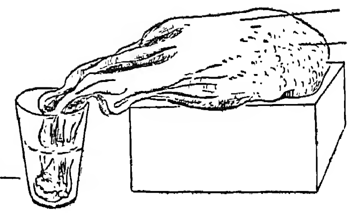


Fig. IX.2. How to germinate seeds on a damp cloth.

Concept 1-c (p. 96): Seeds grow into new plants on getting suitable conditions.

1. Soak a few good bean seeds in water. After one day, plant them close to the sides in a glass jar or bowl filled with good garden soil, so that the seeds are visible from outside. Keep the bowl in a dark place and keep the soil moist. Observe the seeds every day and watch the roots grow downwards and the shoots grow upwards.

2. Place a few seeds of mustard or *methi* on wet blotting papers on two porcelain plates. Keep the papers moist in the germination dishes by adding water periodically. Place one in a dark place and the other on a window sill.

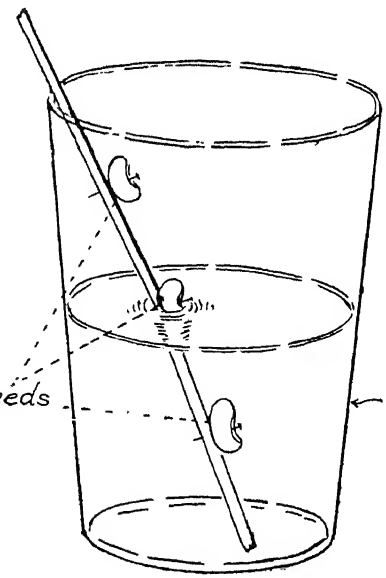


Fig. IX.3. Germinating seeds need air and moisture in proper amounts.

Watch the seeds each day for several days. Observe the tiny plants that grow out of the seeds. In which of the two plates do the seedlings grow stronger and healthier?

3. Take three bean or gourd seeds and fasten them to a pencil at three positions with pins or by pieces of thread, as shown in Fig. IX.3.

Place the pencil in a glass and pour in just enough water to half submerge the middle seed. Now the first seed is well above water, the second has water covering half of it and the third is completely submerged. Keep the glass aside for a few days and pour in enough water each day to make up for the loss due to evaporation. Find out which of the seeds germinates best, and give reasons for the results you obtain. You will find that the seed in the middle germinates best because it has both moisture and enough air.

4. Plant several seeds of bean or gram under different conditions and compare the results. Plant the seeds on cotton in small jars or test tubes. Check such factors as warmth, presence of air, presence of moisture and presence of light. Provide one jar of seeds with warmth, moisture, air, and darkness. Fill one jar with water to keep out the air. Place one jar in a refrigerator, or else pack it in ice in a thermos bottle to keep it cold. Do not add any water to one of the jars.

Which of the above conditions are necessary if seeds are to germinate? Which, if any, are not necessary?

Major Concept 2. The different parts of the flower have different functions.

Concept 2-a,b,c,d (p. 96): (a) Sepals keep internal parts intact.
(b) Petals attract insects.
(c) Stamens provide pollen.
(d) The pistil contains an ovule or ovules which develop into seeds.

1. Examine flowers of the shoe flower, lily, or petunia and note the parts, one by one. With the help of needles, tease out the parts, so that they can be observed clearly. Note that the green stalk ends in a thicker part. This is the receptacle, a part to which all other parts of the flower are attached. The *calyx* consists of green *sepals* and is the outermost part. See how the sepals tightly cover the other parts inside and protect them. Next to the sepals are the delicate coloured *petals* which form the *corolla*. The colour of the petals attracts insects. Note how butterflies and bees hover over brightly coloured flowers.

Remove the corolla. You will now see a ring of filament-like structures, the *stamens*. These are the male organs of the flower. Each stamen has a slender stalk ending in a box-like structure at the tip. These are the *anthers*. Observe these with a lens. Crush one of them lightly between your fingers. You will notice soft yellow dust sticking to your fingers. In nature, when the anthers become ripe, they burst open and throw out small yellow particles called *pollen*.

Remove all the stamens. Now you will find the *pistil*, which is the female part of the flower. The pistil consists of a swollen base, the *ovary* a slender *style* which ends in a thickened sticky part, the *stigma*. Cut the ovary across with a sharp blade and see the structures inside. You will see small round bodies. These are the *ovules* or the future seeds.

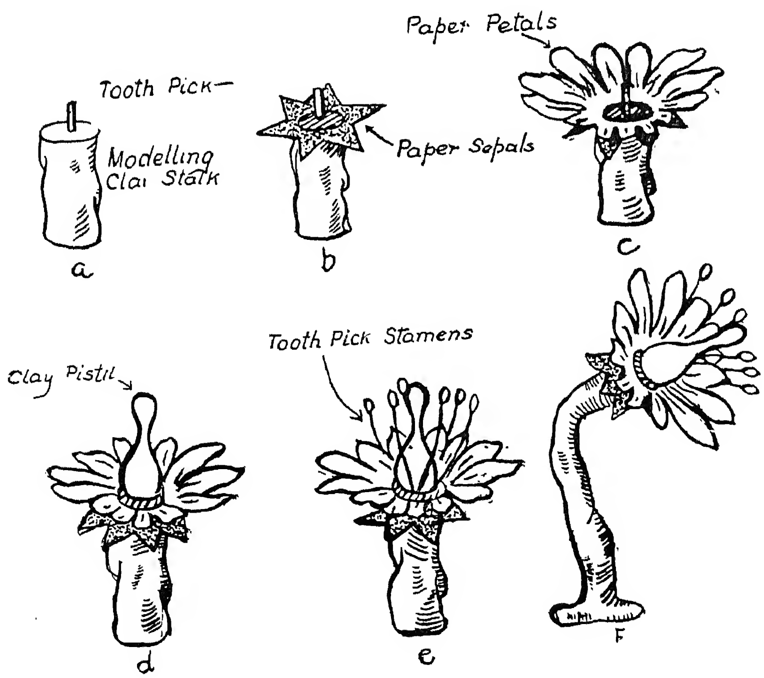


Fig. IX. 4. Model of a flower and its parts.

Examine the pistils of more mature flowers and note the size of the ovules inside. Examine a ripe fruit of the same kind and compare the seeds inside with the ovules.

Draw diagrams of these parts and label them.

2. Make a model of a typical simple flower, using modelling clay, coloured paper and tooth-picks. To do this, roll a piece of modelling clay in the form of a cylinder about 2 cm. in diameter and 5 cm. long (Fig. IX.4). Press one end firmly against the table and push half a tooth-pick into the centre of the opposite end.

To make the sepals, cut a six-pointed star from green paper. Cut a hole in the centre. Place the sepal in position on the stalk as in b.

From brightly coloured paper cut a corolla of petals. Cut a hole in the centre and set the corolla directly over the sepals as in c.

From modelling clay, shape a pistil in the from of a small urn. Press this over the projecting tooth-pick to hold it in place as in d.

Next make stamens by putting on bits of modelling clay on the ends of fine wire. Push these wires into the exposed circle of clay at the base of pistil at c.

3. Examine the stamens in some open flowers. Observe the variety of stamens, the number, length, the shape and size of the anthers and the way the anthers are attached. The anthers will open. Examine the small particles sticking to them with the aid of a lens.

Major Concept 3. Pollination and fertilization are essential processes in the formation of seed.

Concept 3-a,b,c,d (p. 96) : (a) The transfer of pollen grains from the stamens to the pistil is called 'pollination.'
(b) Pollen grains carry the sperms to the egg cell in the ovules.
(c) The fusion of sperms with the egg cell is called 'fertilization.'
(d) After fertilization ovules mature into seeds and the ovary develops into a fruit.

1. Visit a garden or neighbourhood where shrubs and herbs are in flower. Bees and butterflies may be seen hovering over the flowers and landing on some flowers for some time. Then they fly away to other flowers. If you catch a bee or a butterfly, examine its legs and body with a lens. Fig. IX.5 shows how to catch a bee. What is the yellow powder sticking to its body?

The bees visit flowers to gather nectar. The nectar is secreted by glands around the base of the pistil. So the bees have to suck the nectar from deep down. While doing so, they gather pollen on their legs and bodies. When a bee visits another flower what do you think happens to the powder it carries? Some of the pollen gets brushed off its back by the stigma of the other flower.

2. Feel the pollen grains with your fingers. Some are sticky, but others are powdery and loose. Take a flower which is open and dust it on a sheet of dark paper. Examine the powder that has fallen on the sheet of paper.

3. What will happen to the pollen when a strong wind blows? Which type will be carried best by wind? Do you think all of them will reach another flower? Discuss how flowers produce a large amount of pollen which allows for wastage.

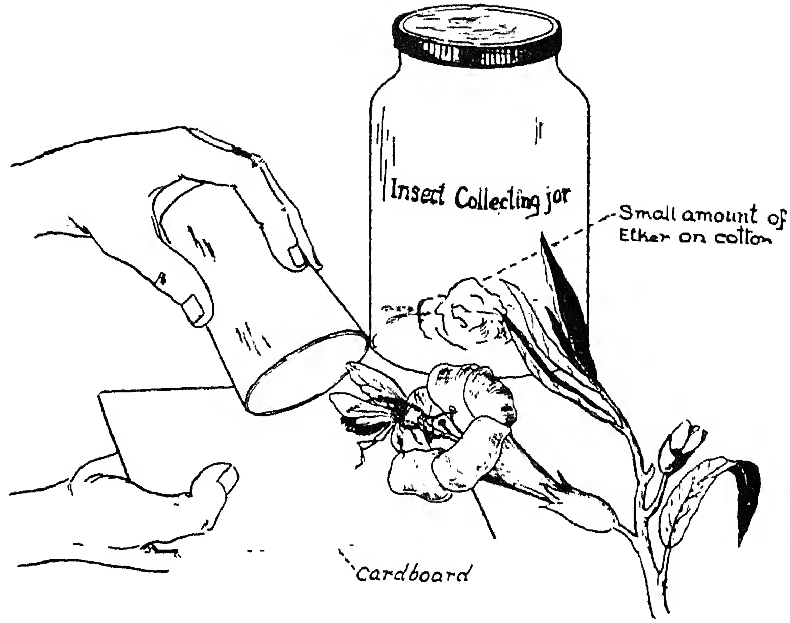


Fig. IX. 5. Catching a bee while it collects nectar and pollen.

Examine with a high magnification hand lens the stigma of a flower on a garden plant. Can you see any pollen grains sticking on the stigma? Observe the stigmas of various kinds of flowers. See how they are broadened and sticky to catch the pollen better.

4. Secure several mature flowers in which the anthers have ripened and the pollen grains have formed. Shake the pollen from each flower on different pieces of dark glazed paper. Observe each type of pollen with a hand lens. Some pollen grains are small; others are big; some are smooth; others have various projections which make them rough (Fig. IX.6).

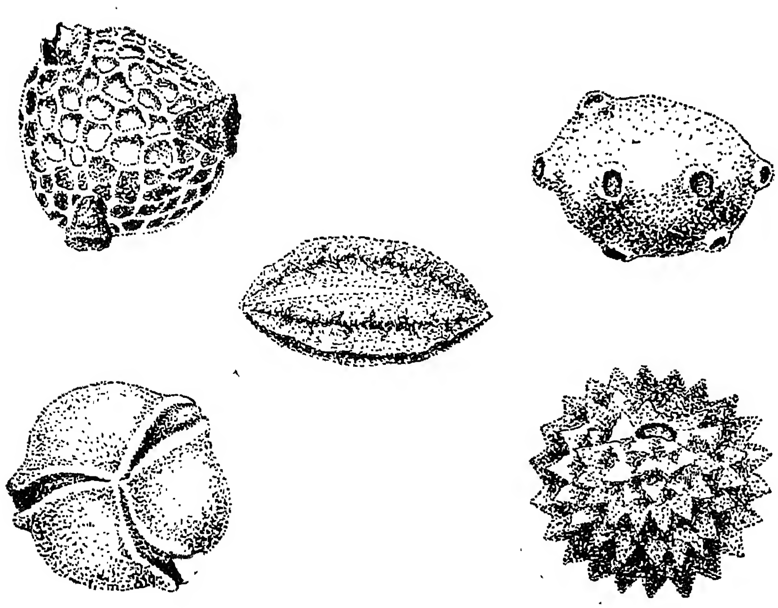


Fig. IX. 6. Pollen grains (magnified).

To show the germination of pollen grains, make a 3% sugar solution in a shallow saucer. Shake pollen from several kinds of flowers on the surface of the sugar solution and let it stand for several hours in a warm place. With the help of a strong hand lens observe the little tubes growing out from the pollen grains. This is what happens when the pollen gets on to the stigma. It begins to grow a long slender tube that pushes its way down through the style into the ovary.

3. To show that the transfer of pollen is essential for the formation of seeds, perform the following experiment in potted plants or garden beds with plants which bear big flowers, such as the poppy, *Hibiscus rosa-sinensis* (gurlal), sweet pea and hollyhock.

Cut the stamens of a few flower buds with a fine scissors and cover such flowers with thin paper caps marked 'A'.

Cover a few ordinary buds with similar thin paper caps marked 'B'.

Cut the stamens of a few other flower buds with a fine scissors. Consider these as flowers of 'C' category. Leave them uncovered.

Let the rest of the ordinary flowers be considered as category 'D'.

After a few weeks, examine several flowers and find out in how many of the flowers seeds have been formed. Record them as in Table IX-1.

What part of a flower seems to be essential for its development into fruit? What is needed before a flower forms fruit or seeds?

TABLE IX-1. FLOWERS OBSERVED WITH REGARD TO STAMENS

Category	Kind of flower	Mark with an *x* if seed has been formed in flower				
A	Without stamens (covered)					
B	Ordinary (covered)					
C	Without stamens (uncovered)					
D	Ordinary (uncovered)					

Cut with a sharp blade the style and ovary of a flower and see if you can observe any pollen tubes.

You will infer from this experiment (1) that it is necessary for pollen from the anther of a flower to reach the stigma of another flower, (*pollination*), and (2) that male cells from the pollen travel through the pollen tube and unite with the egg cell in the ovule to form the seed (*fertilization*).

Find out plants which have separate male and female flowers such as the pumpkin, other gourds and papaya. Examine the two kinds of flowers (male and female). Observe the differences between the two types. Cut vertically with a razor blade one flower of each type. Which one contains ovules? What organs of the flower ultimately develop into fruit?

Major Concept 4. Pollination may be self-pollination or cross-pollination.

Concept 4-a (p. 97): The transfer of pollen from the stamen to the pistil of the same flower is self-pollination.

1. Some plants pollinate themselves, that is, the pollen from the anther of a flower is carried to the stigma of the same flowers. This is done in several ways. The pollen may be carried from the stamen to the stigma by the growth movements of the parts of the flower. The style, as it grows longer, brings the stigma into contact with the anther. Or the anther may stand well above

the stigma so that the pollen is carried down to the stigma by gravity.

2. To find out structures that favour self-pollination examine several different varieties of flowers and note:

(a) Position of the stamens in relation to the floral envelope; that is, whether they are exposed to the wind or shielded.

(b) Position of the anthers in relation to the stigma (whether they are above it or on a lower level).

(c) Character of the pollen produced, i.e., whether it is dry and smooth or moist and sticky, and whether it is produced in large amounts or in small quantities.

(d) Shape and position of the pistil with reference to contact with visiting insects or with wind-blown pollen.

(e) Presence or absence of colour, of scent, or of nectar.

Concept 4-b (p. 97): The transfer of pollen from the stamen to the pistil of another flower is cross-pollination.

1. Most plants, however, continue to have the pollen of one flower fall on the stigma of another flower either on the same plant or on a different plant. This process is called 'cross-pollination.' To ensure cross-pollination, plants have to depend upon outside help to transfer the pollen for them. The wind and moving animals like birds and insects are the most common agents for this.

2. To find structures of a flower which favour cross-pollination, examine several flowers and note:

(a) Whether the flowers are brightly coloured to be seen (a) in the day time, (b) in the night time.

(b) Whether they produce nectar.

(c) Whether they have smell, and if so which type of flowers generally, have smell. Those that bloom in the night or those that bloom in the day?

(d) The time of ripening of stamens and pistil.

(e) The nature of pollen, whether dry or sticky, and the amount produced.

(f) The structure of flower, whether it is specially adapted to the visit of insects;

(g) Whether flowers are unisexual, and if so, whether male and female flowers are on different plants.

Major Concept 5. Cross pollination is accomplished in several ways.

Concept 5-a,b (p. 97): (a) Wind may carry the pollen (maize, *bajra*, pine).
(b) Wind pollinated flowers have special adaptations.
(i) Pollen is produced in abundance;
(ii) Stigmas are usually long and hairy.

Examine carefully the cones of pine and the flowers of wheat, maize or any grass.

Note whether there is any special bright calyx, or corolla, or scent, or nectar.

Note the structure of the ovary and the stamens. Observe that the pollen is light, dry, dusty and produced in plenty. On shaking, large masses of pollen are shed out of the flowers. Observe that the feathery stigma can easily catch the pollen floating in the air.

Make a display of plants which have special adaptations for pollination by wind.

Visit a cornfield. Observe the tassels, which are really bundles of male flowers, and a young cob or ear with silky thread-like filaments. These are the stigmas of the female flowers. Summarize the ways that the flowers of these plants are adapted to ensure pollination by wind.

Concept 5-c, d (p. 97): (c) Insects, particularly bees, butterflies and moths, may carry the pollen (mangoes, peas, *Hibiscus*, lotus.)

(d) Insect polinated flowers have special adaptations.

(i) The petals are coloured.

(ii) They usually have nectar and are fragrant.

(iii) A particular flower may have a close association with a particular insect, e.g., honey bee with sweet pea and *Salvia.*

1. Examine some butterflies and moths which visit flowers and with the help of a hand lens see if you can detect the presence of pollen on their body or on their legs. See pictures of the mouth parts on these insects. Observe how they are equipped with a long sucking tube to suck the nectar from deep inside the flower.

2. Examine some flowers regularly visited by insects, bees, moths and butterflies, such as the bean, mango, *Hibiscus*, poppy, lotus, or brinjal, and note the following:

(a) Whether the petals are brightly coloured.

(b) If there is any strong scent.

(c) If there is honey or nectar.

(d) Whether the pollen is loose, light and dusty or otherwise.

(e) Whether the stigma is dry and hairy or sticky.

3. To show that some flowers are so constructed that they can attract only one kind of insect, e.g., honey bee, examine a *Salvia* flower (Fig. IX.7). Remove carefully the petals and see how the stamen is attached. One arm is big and another short, and if, at the place of attachment the plate-like structure is pushed, the longer arm bends down.

What will happen if the bee in search of honey pushes this piece?

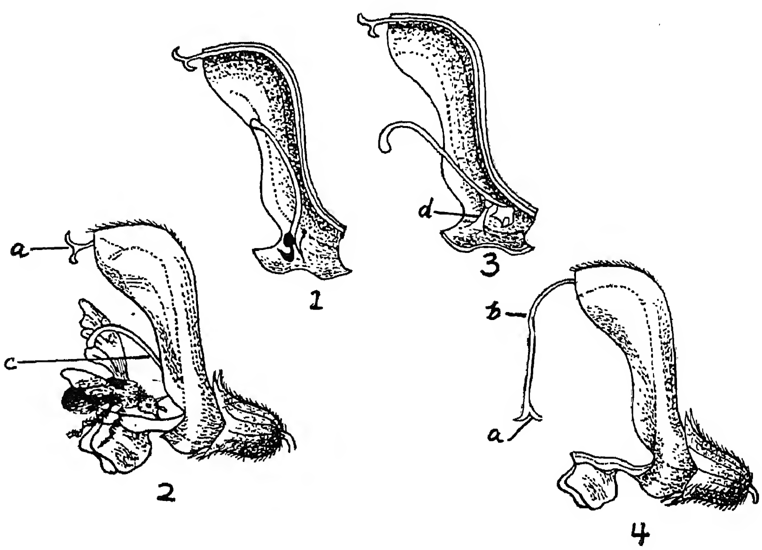


Fig. IX.7. Honey bee visits *Salvia* flowers.

a—stigma
b—style
c—anther
d—filament of stamen

The anther is a peculiar structure in this flower. It is attached to the filament in such away that it swings easily on the point of attachment (3) and has a long arm and a short arm. The stamen is at first erect (1). When the bee rests on the lower lip (2 and 3) of the petals, the head of the bee pushes the short arm of stamen and the long arm bends and dusts the back of the bee with pollen. When the bee visits another older flower where the anther has already shed its pollen, the style which is curved touches the back of the bee and in that process lifts some pollen off the back of the bee on its sticky stigma (4).

Concept 5-e (p 97): Special devices in many flowers prevent self-pollination.
(i) Flowers may be unisexual (gourd, palm, maize, date).
(ii) Stamens and pistil mature at different times (aster, *Salvia*).
(iii) Location of stamens does not favour self-pollination (primrose).

Self-pollination is prevented in many ways in plants. Examine the following:

(a) Unisexual flowers like those of gourd, melons, papaya.

(b) Flowers in which stamens and pistil mature at different times, as *Salvia*, aster.

(c) Location of stamens which is unfavourable for self-pollination, as in the primrose.

In the previous case of the *Salvia* flower (Fig. IX.7) which matures first, anther or pistil? When the anther is dusting the back of the bee, where is the stigma?

Major Concept 6. While flowering plants are generally propagated by seeds, some are easily propagated by vegetative means.

Concept 6-a (p. 97): Certain plants are propagated from cuttings (sugarcane, sweet potato, tapioca and rose).

Take a cutting of a plant with a few buds on it. Cut a part of a branch which is neither very hard nor very soft with a sharp knife, and plant this cutting in soil under a shade. After some time, new shoots start above the ground and the part underground produces roots. Remove a few sprouting cuttings from the soil and examine them. Visit a nursery or a garden and observe how roses, crotons, and other garden plants are propagated by cuttings.

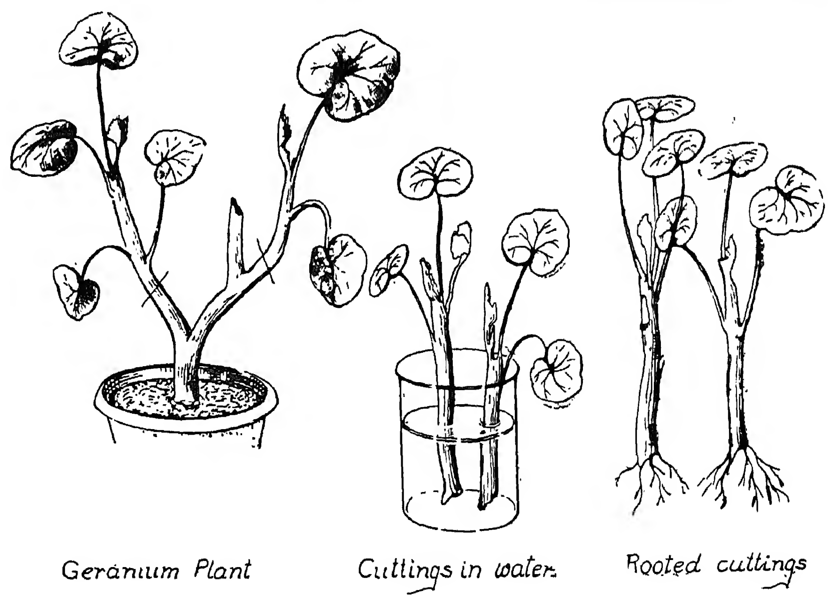


Fig. IX.8. Some plants can be propagated from cuttings.

Concept 6-b (p. 97): Certain plants are propagated by grafting (citrus, mango).

Select a sturdy rose plant as *stock*. From another rose plant of an improved variety, cut a branching stem with a few buds, to be used as a *scion* for either a tongue or a cleft graft. Cut a similar groove in the stock with a sharp knife. Fit the scion on the stock, wrap it tightly with a soft thread and cover it with grafting wax to prevent drying and infection.

Visit a nursery and observe the grafting of mango and citrus plants. When grafting, be sure that the soft inner layer of the bark of the stock and the scion are in close contact with each other.

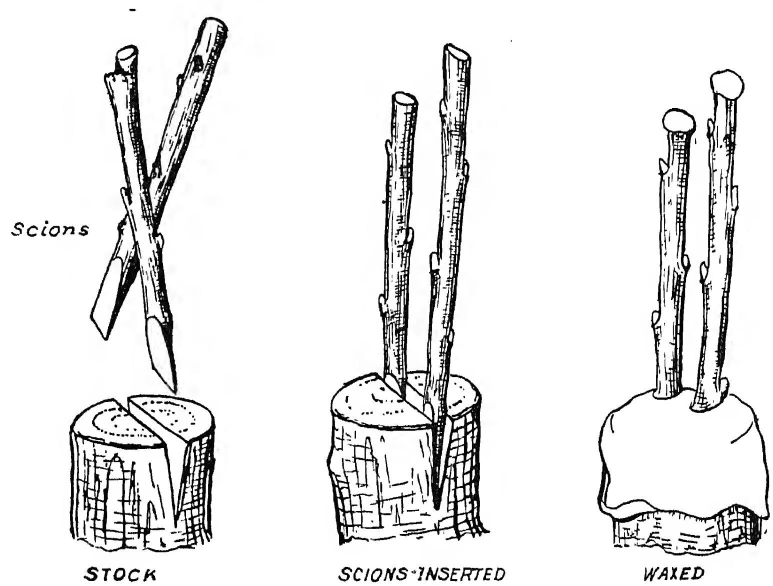


Fig. IX.9. Cleft and tongue grafting.

Concept 6-c (p. 98): Certain plants are propagated by budding (rose, mango, orange, apple).

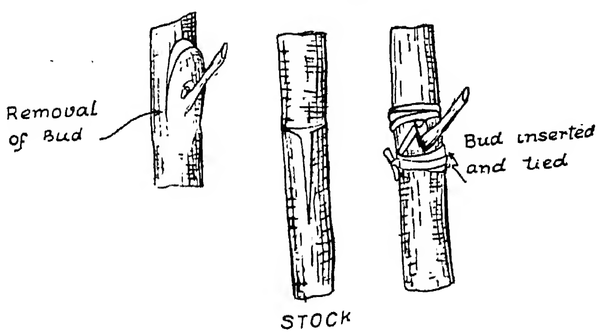


Fig. IX.10. Making a bud graft.

To show budding, cut a shield-shaped piece of scion plant (scion) with wood containing a single bud. Insert this carefully in a T-shaped cut in the stem of the stock. Both grafted and budded sites are wrapped tightly to hold stock and scion together. The cut surfaces are covered with grafting wax to protect the tissues from drying and from fungus infection.

Concept 6-d (p. 98): Certain plants are propagated by layering (mint, lemon).

To show propagation by layering, visit a garden plot where mint plants are grown.

Dig a small pit some distance from the plant. Bend a branch into the pit and cover that portion with earth, allowing the rest to remain above the ground. Place a few pieces of stone as weight on the earth. After a few days, the part under the ground will have developed roots. Now this branch can be cut from the parent plant and planted elsewhere as a new plant.

Concept 6-e (p. 98): Certain plants are propagated by tubers, corms, bulbs or root-tubers (potato, banana, ginger, onion, dahlia).

Take a potato tuber, the corm of *Colocasia* (*arbi*), tubers of dahlia, bulbs of onion and garlic, a rhizome of ginger or turmeric, or similar vegetative parts. Plant one or two items of each of the above in flower pots or in garden plots. Irrigate them to keep the soil moist and observe the new plants growing.

Concept 6-f (p. 98) : Certain plants are propagated by leaves (*Bryophyllum*, *Begonia*).

Cut a small piece of a leaf of *Bryophyllum* or *Begonia*. Put this on moist sand in a pot or a glass dish and observe it every now and then. You can even hang up a leaf of *Bryophyllum* by a piece of thread and observe what happens every day. After one or two days note the margins of the leaves. You will find tiny leaves and buds and roots also. Allow them to grow into big plants. Then separate the small plants from the leaf and plant them separately in a pot. You have started a new plant from the leaf of the parent plant.

Major Concept 7. Non-flowering plants are reproduced by spores.

Concept 7-a,b (p. 98): (a) Certain plants do not bear flowers. Ferns and mushrooms are non-flowering plants.

(b) Such plants bear spores which, like the seed, can lay dormant for long periods. Spores are light and are readily blown by the wind.

1. Examine plants of ferns, mosses, fungi, and algae from ponds, to see if any flowers are borne on them.

2. Examine with a hand lens the spores on the under side of fern leaves and in the spore capsules of mosses.

Moisten some bread. Expose it to the air and dust for 10 to 15 minutes. Then cover it

with an inverted glass tumbler and set it in a damp place for several days. You will notice a soft white growth which will later darken in colour at the top. With a hand lens, observe the black dots. These are the fruiting bodies (*sporangia*) which produce *spores*. How are spores spread from plant to plant?

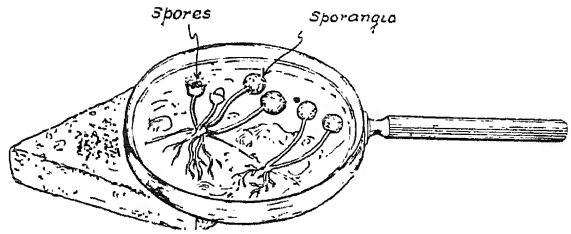


Fig. IX.11. Black mould on bread seen through a hand lens.

Concept 7-c (p. 98): The spores germinate under suitable conditions and ultimately form new plants.

Take four slices of bread. Exposing as little as possible to the air, place one slice in a covered container in a dark place. Also exposing it as little as possible to the air, place a second slice in a covered box or dish where it will get plenty of light. The third slice should be exposed to air in the classroom for half a day, then put away in a warm dark place in a covered container. The fourth slice should be placed in an open saucer where it is allowed to dry out. Which slice develops mould fastest? What do you conclude about growing mould spores? Do dampness, warmth, and the absence of light speed up the growth process?

Major Concept 1. The structure of the root is adapted to its many functions.

Concept 1-a (p. 98): Roots anchor plants (fibrous and tap roots).

1. Try to pull out several types of plants—common grass, a small weed and a big weed. Feel the force required to pull out the plants. You have to apply some force (more or less) to pull out the plants. What anchors the plants to the soil?

2. Dig out carefully various types of small plants (like balsam, *Cassia*, *Tridax*, a grass, marigold or a radish) without tearing any of the roots. To do this, loosen the soil around the plant with a shovel or stick and observe whether the roots are of the tap or of the fibrous type. Tabulate your findings in a table How deep do the tap roots grow? How deep and wide do the fibrous roots spread?

Concept 1-b (p. 98): Roots absorb water and minerals. Absorption takes place through root hairs near the tips of the roots.

1. Germinate a few seeds of mustard placed on wet blotting paper which is itself placed on a glass plate. Cover the plate by inverting a beaker or a glass jar over it. Place it in a warm place. Keep the paper moist by adding small quantities of water to the blotting paper periodically. Observe every day until the seeds have sprouted. Examine the young roots with a hand lens. Note the fine root hairs. Where do they occur on the root? Does the root increase in length at the tip? At the position of the root hairs? Back of the root hairs? What would happen to the root hairs if the roots increased in length back of them? Mark on the blotting paper the position of the tip of the root and of the front of the root hair zone. Then observe their position on successive days. (You will be interested to know that each root hair is an extension of a cell near the tip of the root.)

2. To show that roots absorb water and minerals, take three similar seedlings of balsam from the garden with their roots intact. Do not let them dry out. Place them in three bottles, bottle (a) containing water, bottle (b) containing water coloured with cosin or red ink, and bottle (c) containing water with a suspension of brick powder.

Let the roots alone dip into the liquids. Cover the bottles with black paper. Observe the seed-

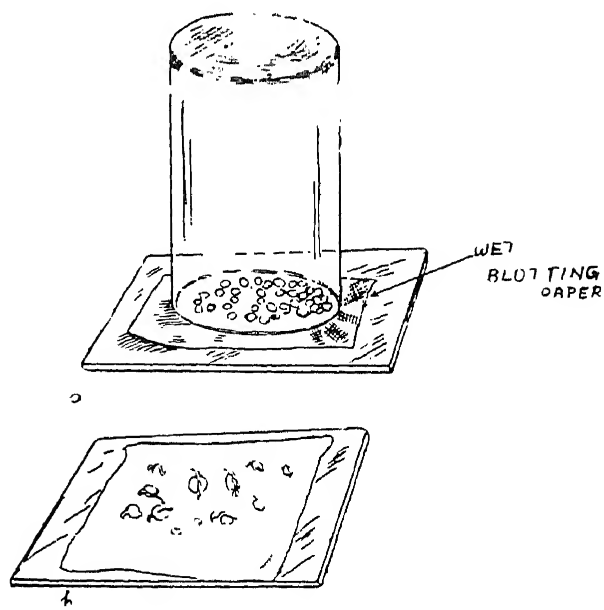


Fig. IX.12. Germination of seeds to grow root hairs.

lings for several days. Do all the seedlings absorb water? Which, if any, seedlings have absorbed the colour? How?

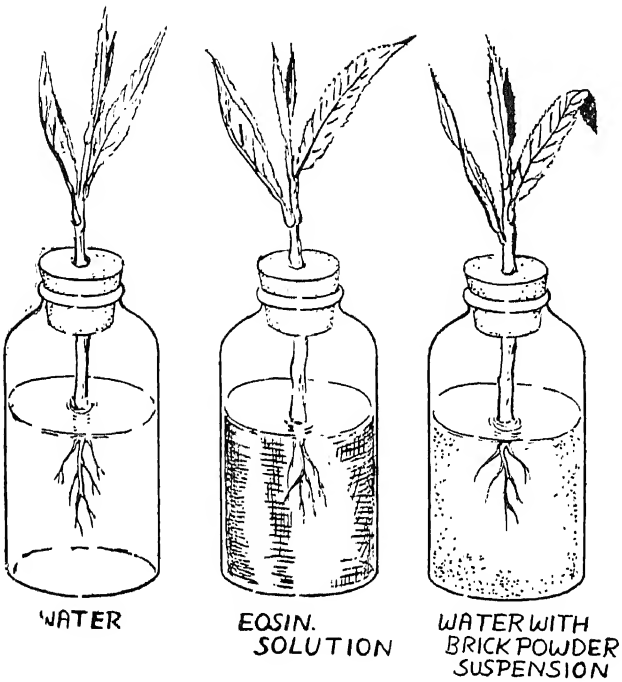


Fig. IX. 13. Roots absorb water and minerals.

3. To show the way roots absorb water by osmosis, do this experiment.

Select a carrot with a large top. Cut a hollow in the top with a sharp knife to a depth of 2 or 2.5 cm. Do not split the top in the process. Fill this hollow with sugar solution. Insert a one-holed rubber stopper or cork fitted with a glass tube in the hole. Place the carrot in a wide-mouthed glass half-filled with water and set it aside. Observe once every 24 hours. Note the level to which the sugar solution has risen in the glass tube. How did the sugar solution rise?

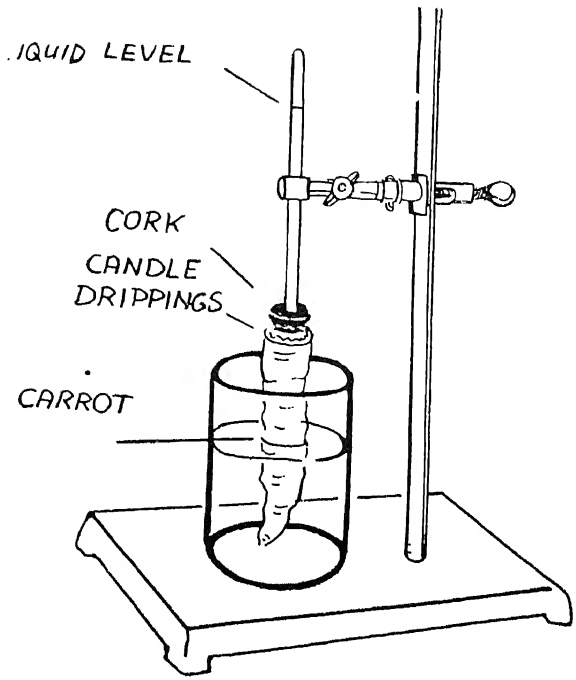


Fig. IX. 14. A carrot-osmometer.

Note: If this cut at the top is not air-tight, seal the opening with molten wax from a candle. Instead of a carrot, a radish, beet or turnip may be used. A slotted card can be devised to hold the vegetable in the solution if a ring stand is not available. (Refer to Fig. IX.22).

Concept 1-c (p. 98): Food accumulates in certain roots (tapioca, radish, carrot, beet and sweet potato).

1. Make a collection of the following roots: beet, carrot, radish, dahlia, sweet potato, khus grass, asparagus and tapioca. Some of these are swollen and edible. In what way is the food in these roots utilized by the plant? Compare the growth of these plants with other plants such as the tomato, the marigold, or *Zinnia*.

2. Take a healthy radish or carrot and cut

the leaves and also the lower part so as to leave about 10-15 cms. from the base. Scoop out the central part in the top with a knife to make a hollow cylinder about 2-3 cms. wide. Pierce it with two *pins at right angles* and suspend the root from a nail in an open place Fig. IX.15. Pour water in the hollow cavity.

Watch the radish or carrot for some days, taking care to keep the hollow cavity constantly re-filled with water.

New shoots grow from the base. From where did the shoots get the food? Note how the shoots grow upwards.

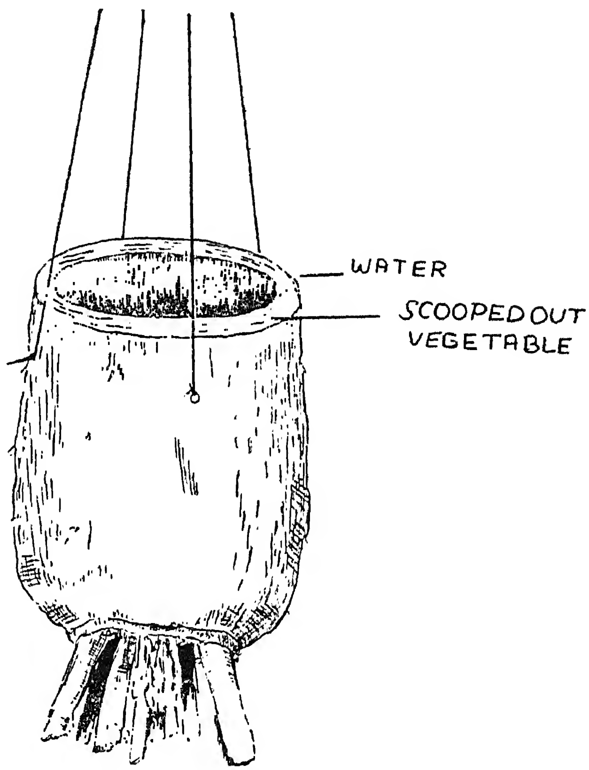


Fig. IX.15. Will new shoots grow if water is provided ?

Major Concept 2. The structure of the stem is adapted to its many functions.

Concept 2-a (p. 98): The stem supports and bears the leaves.

Observe any large tree. Look at its branches, twigs and leaves. What part of the tree bears all this weight? Observe a creeper or a twiner. Note how the leaves are attached and arranged on the stem. Are they arranged alternately, oppositely, spirally or in whorls? Can you see the advantage to the plant of this arrangement? (Explain how light is essential for the leaves to carry out photosynthesis and how the arrangement of the leaves allows for the maximum light without throwing other leaves into shade.)

Concept 2-b (p. 98): The transport of materials between the leaves and the roots takes place through the stem.

Take a balsam plant. Cut all roots except the main root while the plant is immersed in a basin of water. Insert the plant in a wide-mouthed bottle containing water coloured with red ink. Observe after a few hours or overnight. Do you see streaks of colour in the stem and in the veins of the leaves? With a razor blade take a thin section of the stem and if possible of a leaf. Observe the sections through a hand lens. Note the parts coloured red. Notice where the colour went in the leaves. Hold the leaves up to the light and compare with leaves of another plant. What do you conclude?

Concept 2-c (p. 98): Food accumulates in certain stems (sugarcane, potato).

Collect stems of plants such as the sugarcane, potato (tuber), ginger, *arbi* (*Colocasia*), turmeric and yam. Note the swollen nature of most of these. How do you know they are stems? Note the presence of scale leaves and buds on them. In what way does this accumulated food serve the plants? In what form is the food stored in sugarcane and in what form in the other plants?

Concept 2-d (p. 98): The stems of certain plants can be used for vegetative propagation (sugarcane, potato, doob grass).

Observe a potato tuber closely. Note the 'eyes'. These are the nodes. In each node is a small bud. When you keep potato in storage for some time you can observe these 'eyes' beginning to sprout. Cut a potato into four pieces. Bury the pieces in a pot filled with soil. See how they sprout and send up fresh shoots and become new plants. You can get a new yam plant by planting the top part containing the bud. Visit a vegetable farm and see how potato, onions, yam, ginger, etc., are raised.

Major Concept 3. The structure of leaves is adapted to their specialized functions.

Concept 3-a (p. 99): The main function of the leaf is photosynthesis. Other functions are respiration and transpiration.

1. To show that leaves give off water vapour, take two potted plants. Cover the soil in each pot with cellophane paper, tin foil, or cardboard. Remove all the leaves from one of the plants. Invert a glass jar over each plant. Place the pots in the sun and examine them from time to time during the day. What difference do you find on the inner sides of the inverted jars? Has moisture collected?

2. To show that food is manufactured in the leaves of plants, select two potted plants. Keep

one in a dark room for 24 hours before the experiment, and the other in direct sunlight.

Take two leaves from the plant in the open and boil them in water. The leaves will become limp. Later take the leaves and place them in alcohol in a beaker. Place this beaker in a pan of water and heat the water for about five minutes. (Take care not to allow the alcohol to catch fire). Remove the beaker from the fire and allow the alcohol to cool. Remove the leaves and wash them with water. What is the colour of the leaves after the treatment? What is the colour of the alcohol? What is this new substance in the alcohol? (green chlorophyll).

Now place the treated leaves on a glass plate and add a drop of dilute iodine solution. Tincture of iodine may be used. (Iodine solution is made by dissolving 0.3 gm. of potassium iodide in a little water and adding 0.3 gm. of iodine crystals and adding water up to 100 ml.) This iodine solution may be diluted as desired. What is the change of colour produced in the leaves? Do the leaves turn blue or black? What does this indicate? (the presence of starch in the leaves, which is an index of photosynthesis.)

Repeat the experiment with two leaves from the plant kept in the dark. What is the difference in the colour of the treated leaves? (You will note that when iodine is used, the leaves remain brown, the colour of iodine, showing the absence of starch.)

Note: To learn that iodine reacts with starch and turns it blue, make a suspension of starch in water. (Wheat or rice starch may be used.) Warm it a little and add a few drops of the iodine solution. Note the blue colour that starch takes on. You will find this a useful test for the presence of starch.

Concept 3-b (p. 99): The under surface of the leaf contains numerous minute openings called 'stomata' through which water vapour and air pass.

1. Take from a plant three broad leaves with stalks. Smear their surfaces with vaseline as follows: leaf (1) on both sides, leaf (2) on the underside, and leaf (3) on the upper side.

Hang all the three leaves from a string and leave them for a few hours. Observe the degree of wilting in each of the leaves. Find out which leaf has wilted the most? Why?

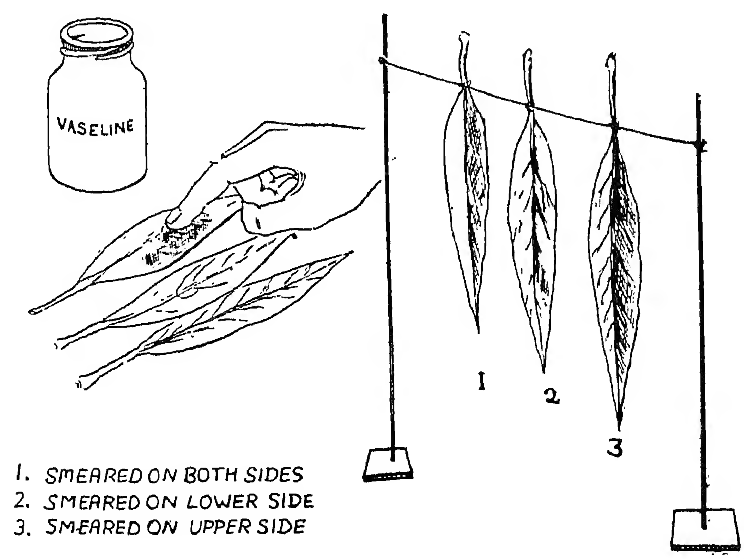


Fig. IX.16. An experiment to show which side of the leaf has more stomata.

2. Take a leaf with a long stalk and insert it through one hole of a two-holed cork. Through the other insert a short L-shaped tube. Fit the cork to a bottle of water, allowing the leaf stalk to dip into the water. Seal the hole with vaseline. Now suck air from the short glass tube. Air bubbles will issue from the stalk of the leaf. Where has this air come from?

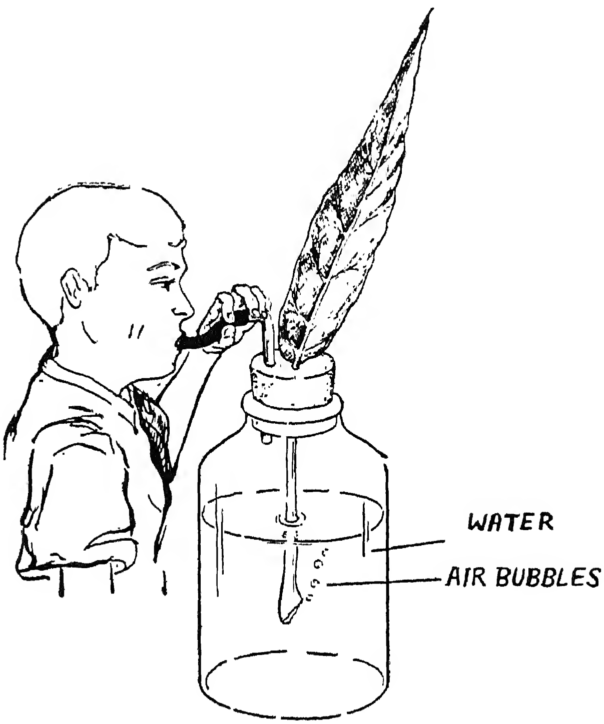


Fig. IX.17. Air enters through stomata.

3. To show the presence of stomata on the leaves: Take the leaf of *Hibiscus*, cabbage, radish, or any broad one. Peel off a small piece from the under surface. Place this peel in a drop of water on a glass slide and cover it with a thin cover glass. Examine the peel under a microscope. You can observe openings or stomata between the large surface cells. Draw diagrams of what you see.

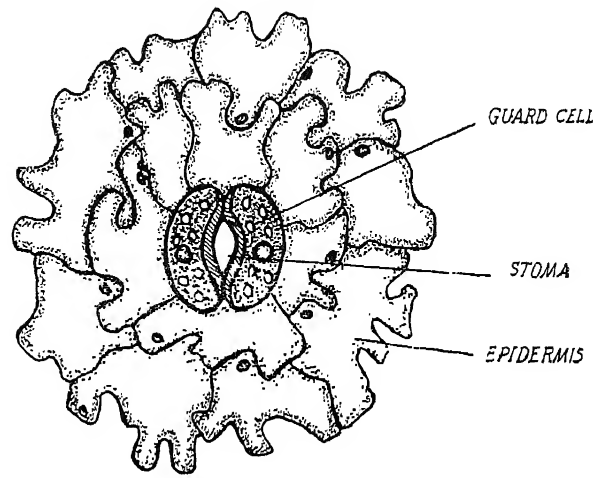


Fig. IX.18. A leaf section showing a stoma magnifed.

4. Cut a thin section across a leaf with a razor. The leaf can be held between split pieces of pith and the leaf cut along with the pith. Mount a section in a drop of water as before and examine under the microscope. The stomata with guard cells can be made out in the epidermis, with more on the lower surface. Note the other tissues in the leaf also.

Concept 3-c (p. 99): Veins carry water to the leaf, and food from the leaf to the other parts of the plant.

Do the same experiment as for 2-b. Note the colour in the veins of the leaf. This shows that water has travelled along all the veins in the leaf and has reached every cell in the leaf.

Concept 3-d,e (p. 99): (d) A waxy coating prevents excess loss of water. This is especially marked in plants growing in dry regions.
(e) Plants growing where rainfall is heavy have pointed leaves (drip-tip) and waxy coatings which shed water readily.

1. Collect and bring to the school several types of leaves; some thin and broad, some thick and fleshy, some stiff and leathery and others with a waxy coating on them. Hang all the leaves by

their stalks. Note which leaf withers most. Observe that the leaf with waxy coating withers the least. Why? Find out in what kind of climate or soil conditions these various plants grow.

2. To show that a pointed tip tends to shed water, dip both rounded leaves and pointed leaves in water, then lift them out of the water and see which sheds water faster.

3. Discuss how in rain forests, where rainfall is very heavy, there must be some provision for water to run off the leaves; otherwise they will be weighted down by water and so not capture as much sunlight. Also the stomata will not perform their function as well, namely, that of letting air in and letting out the water, i.e., through transpiration.

4. Discuss how transpiration is necessary, but at the same time should be regulated so that the plant does not lose more water than it can replenish. Discuss how the stomata open in light as the guard cells manufacture sugar and water moves into the cells making them turgid. Point out that as water evaporates from the guard cells they become limp and close the pore.

Major Concept 1. Crop yield can be improved by various methods.

Concept 1-a (p. 99): Plant and animal manures are used to increase the fertility of the soil.

1. Visit a farm land while it is being ploughed. You will find piles of dark-coloured rubbish heaped here and there. Feel a little of this material between your fingers. You will feel that it is light and powdery and you may find in it bits of dried and decayed leaves and animal refuse. The farmer will tell you that this is manure which makes his land rich and fertile. Why? This material contains minerals needed for plant growth. It also improves the water-holding capacity of the soil. Can you devise an experiment to test this?

2. Put a little garden soil in a tall jar. Pour into it water and stir well. Allow the matter to settle down. Note the different layers of materials. What is the dusty material at the top? What is it called? (Humus). How is this useful to plants?

3. Observe compost pits in gardens. Find out how the gardener makes compost. Does he get animal manure from outside? Does he add vegetable matter? Does he add any chemicals to help in decomposing the animal and vegetable matter?

4. To see how humus is made, cut some leaves into pieces and dry them in the sun. Put them at the bottom of a glass or a wide-mouthed bottle, up to 5 cm. deep. Cover the leaf layer with a thin layer of ash. Pour a little water to make the layers wet. Repeat the same with addition of layers of powdered dry leaves and ash in alternate layers. A little garden soil may also be added to one of the layers. Keep the layers damp and finally cover them with cotton wool to prevent quick evaporation of water. Observe the bottle every day and see the change of colour of leaves from pale brown to dark brown and then to black. Feel the warmth of the bottle. When finally every thing has turned dark in the bottle, you have made good compost. (Refer to Fig. VIII.10.)

5. Prepare several flower pots. In one, place only sand; in another only clay, and in the third a mixture of sand and clay, and in the fourth a mixture of sand, clay, and humus. Place soaked beans or mustard in each and keep the soil moist. After a few days observe in which kind of soil the growth of seedlings is the best. Be sure to maintain the same moisture and light conditions for all the four pots.

Concept 1-b (p. 99): A seed bed should be carefully prepared by deep ploughing and harrowing.

To show that a seed bed should be carefully prepared by deep ploughing and harrowing, take two samples of soils: one that is finely grained and the other in coarse lumps. Place them in equal-sized boxes. Plant bean seeds which have been soaked overnight in the two boxes, being careful not to break any lumps. Water both boxes. Set the boxes in a warm place and observe

results from day to day. Do the seeds grow alike in both boxes? Does the soil dry out faster in one box than in the other? Why? Which method of preparing the soil promotes better growth?

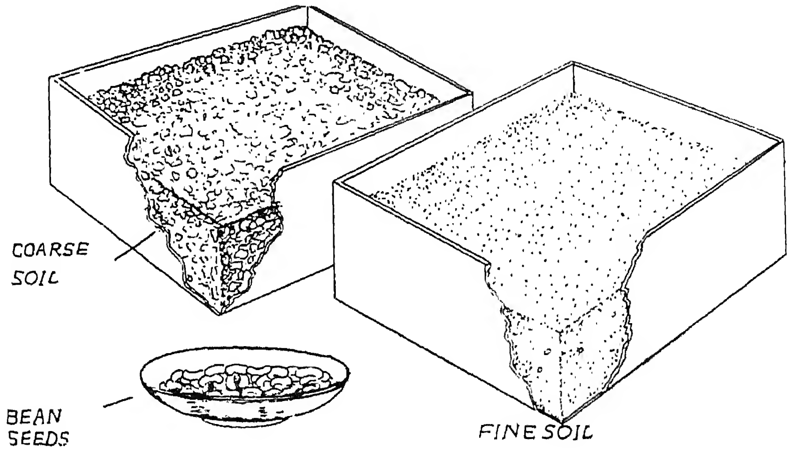


Fig. IX. 19. Making a seed bed.

Concept 1-c (p. 99): Lime is added to neutralize acidity where needed.

Visit the Block Development Centre in or near your village. Find out if lime is added to the local soils. What plants require lime and what plants do not? How can the farmer know if he should add lime to his soil? Talk with the agriculturist at the centre about these questions. He may come to your class to discuss this matter.

Concept 1-d (p. 99): Chemical fertilizers are used to enrich the mineral content of the soil.

Visit any plantation nearby: sugarcane, tea, coffee, paddy, wheat, vegetables, or visit an orchard of fruit trees. See whether the planter uses any chemical fertilizer besides the organic manures. Make a list of chemical fertilizers and learn about the uses of different fertilizers for different crops. What minerals do they contain? What percentage of each mineral is present? Find out the part which each of these minerals play in the healthy growth of the plant. (See Table IX—4.)

Concept 1-e (p. 99): Healthy seeds of a productive variety give a better yield.

1. To show that healthy seeds give better yield, test the seeds for germinating quality (as in activity 1 under concept 1-c, in class VI of this unit).

Take two samples of seeds of bean or some other plant, one healthy looking and another not. Or select two samples of seeds of the same variety, one of large seeds and one of small seeds. Soak the seeds for some time and then place them between two wet blotting sheets on a plate. Cover the plate with another, but not airtight. Do this for each sample of seeds separately, and keep the

plates in a warm place. After 48 hours, examine the number of seeds that have germinated. Calculate the approximate percentage in each sample. Examine the seeds that did not germinate to observe whether they were well-developed or not. Make a chart of your findings.

2. To show that seeds of a productive variety give better yield, procure from a nursery or the Block Development Centre seeds of an improved variety of a vegetable like *bhindi* or *baingan* (egg-plant), and another packet of seeds of an ordinary variety from the market. Plant some soaked seeds from both the packets in between plates and see how they germinate. Sow the rest of the seeds in two separate plots in the garden. Observe which variety gives better percentage of germination and which plot gives better yielding plants. Explain the reasons for the differences you observe. Find out how certified seeds are prepared.

Concept 1-f (p. 99): Seeds should be planted properly spaced and at the right depth.

To show that seeds should be planted at the right depth, prepare seed beds carefully and plant seeds at different depths in marked out areas. Cover the seeds with firmly packed sandy soil. Moisten the seeds each day. See which of these seeds have germinated well and note the depth at which they were planted. About two to three times the length of the seed is the proper depth.

Concept 1-g (p. 99): Stirring the soil by cultivation aerates it, increases the growth of nitrogen fixing bacteria, and kills weeds.

Take two garden plots. Turn up one well and prepare the bed carefully. Leave the other plot not so well prepared. Sow some bean seeds in the two beds. Observe the growth of the plants in the two beds. With the same amount of water supply, why do plants of the first plot wilt sooner? What is the place of earthworms in soil aeration? (Refer to Unit X, Class VI, 3a.)

The study of nitrogen-fixing bacteria will be pursued under Concept 4.

Go out to the fields in the sowing season and see how the farmer prepares the soil before sowing. Observe how the gardener turns up the soil around the roots of plots periodically.

Concept 1-h (p. 99): Rotation of crops and green manuring improve yields.

Visit a farm and find out whether the farmer plants crops in rotation or whether he plants the same kind year after year. If he adopts the former method, write out a list of crops he plants and the order in which he plants them. Discuss with a farmer the reasons why he does so. Interview an agriculture officer about crop rotation.

Green manuring consists of ploughing into the land a leafy crop or green twigs and branches.

Make a list of green manure crops that a farmer uses. He may either grow them in his field and plough them in, or obtain them from another site to bury in the soil. Were *Crotalaria* or mustard used? In what way does this procedure benefit the land and the farmer? What do these green manure crops have in common that makes them enrich the soil? If you were a farmer, would you prefer to plough in some of your crops, or just feed them to your stock? Explain your belief.

Concept 1-i (p. 99): Spraying with certain chemicals protects plants from disease-producing insects, fungi and microbes.

Visit a school or kitchen garden. Observe the plants carefully. If they are all healthy, it is certainly a great credit to the gardener. Often, however, you will notice some plants not so healthy. The leaves are eaten up, look pale and unhealthy or the whole plant is stunted. Observe any diseased plant. Observe whether the plant is attacked by any insect. If so, try to collect the eggs and adult stages of the insect. Note the damage done. Did the insect have chewing mouth parts or sucking mouth parts? How else can plants be damaged by insects?

Select any diseased plant and spray the affected parts with an insecticide or fungicide. After a few days note if any new healthy shoots come up. Continue spraying according to directions given for the insecticide to prevent the new shoots from being affected. Note the results.

Visit a farm and collect information from the farmer about the most common pests that attack his crops, the stage at which they do so, the plant parts which are affected, and the precautions which he takes. Tabulate your data.

Study books and newspaper reports about blights which have affected crops in a large scale and sometimes even caused famine. (The potato faminine in Ireland, rice famines, etc.)

Visit the Block Development Office or contact the Agriculture Laison Officer and find out how they help farmers with insecticides. Find out their sources and what they are composed of. How does the farmer apply the insecticides to large areas of crops? Have you heard of dusting plants with insecticides by aeroplane? Does the *mali* in your home garden use a chemical to keep insects away from the flowers? Find out more about this.

Major Concept 2. Science is used to improve the varieties of plants.

Concept 2-a (p. 100): Seeds of the best plants are selected for use for raising the next crop.

Visit a vegetable garden and select a crop of *bhindi* or bean. In the plot of *bhindi* select a very healthy plant and one poor looking, stunted plant. Select some good fruits to ripen and dry on the plant. Tag this plant so that you can watch it and collect the seeds.

To prevent scattering of seeds when the fruit splits open, bag the selected fruits either with a small cloth bag or a paper bag. When the fruits have opened, collect the seeds, dry them and repeat a germination test separately with seeds of the healthy plant and those of the poor looking plant. Note the percentage of seeds germinating in each case. Repeat this experiment to verify your observations. Do more of the seeds of the healthy plant germinate?

Sow some seeds of the two types in seed beds and raise the plants. Be sure to maintain similar conditions for plant growth (except the seeds). Which seeds give rise to good healthy plants?

Visit a farm or a nursery and find out how the best seeds are selected and preserved for the next year's crop.

Concept 2-b (p. 100): Plants with desirable qualities are crossed. The offspring are selected and tested for desirable qualities.

Visit an Agricultural Research Station or a Fruit Research Station and observe the research workers carrying on hybridization work. Note how they cross two varieties, each of which has some desirable qualities. You will observe how the pollen of the male parent of one variety is collected and dusted on the pistil of the female parent of another variety. Then the pistil is bagged to allow the fruit to develop and to prevent pollen of any other plant from reaching the pistil. Observe also how the offspring are selected and tested.

Visit a mango grove and find out how the planters develop new and superior varieties by grafting two varieties.

Do this experiment to show how plants with desirable qualities are crossed. One variety of rose has red roses but blooms only one or two weeks; the other variety has pale pink roses that bloom all summer. How can one get, by crossing the two, a beautiful red rose that will bloom all summer. Choose the plant with a red rose as the male parent. Choose a ripe flower. Remove all its anthers with a pair of tweezers (forceps) which have been previously sterilized. Place all anthers in a container, as shown in Fig. IX.20.b.

Choose a flower about to open in the female plant. (the pink rose). Remove all petals and stamens from this flower. Take care that no pollen from this flower falls on the pistil. Why? As soon as the pistils are ready, take the pollen collected earlier on a brush and rub this pistil

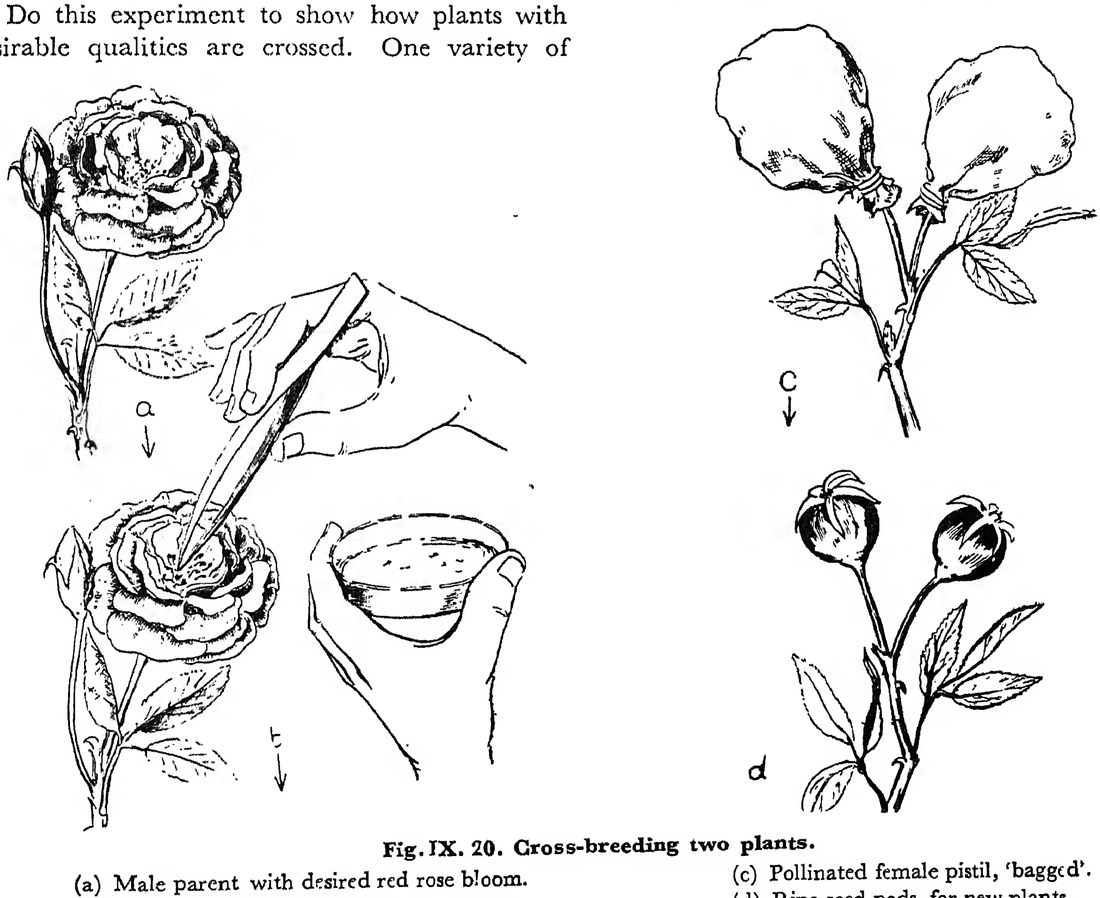


Fig. IX. 20. Cross-breeding two plants.

(a) Male parent with desired red rose bloom.
(b) Pollen being collected from male parent.
(c) Pollinated female pistil, 'bagged'.
(d) Ripe seed pods, for new plants.

with it. Place a paper bag over the pistil to prevent other pollen from reaching this pistil. Place a tag over the bag giving details of the parent plants. Wait until seeds develop. Plant them. Do they produce a plant with the desired red blossoms ? More than one flower may be so treated to get a number of seeds.

The process used with the roses may be repeated with *bhindi* or corn. Guidance from an expert is necessary.

Visit a flower show and study how people have developed new and superior varieties of flowers—day lilies, chrysanthemums, roses, dahlias, etc., by this process of crossing. The process of growing new roses from seed is long; you may be able to visit a fine garden to observe this going on.

Concept 2-c (p. 100) : Productive varieties with desirable qualities may be multiplied by their seed or by vegetative methods.

Collect seeds after experiments in crossing as described in the previous activity. Sow them in well prepared beds and raise the plants. Note whether they have the desired qualities, i.e., whether they show the two qualities you brought together in your crossing experiment.

A few interested students may wish to continue the project.

Collect seeds from the hybrid and sow them. Note whether the second generation of plants resembles the first with regard to the desired qualities.

Some plants, when raised from seeds, lose the qualities of the hybrid. Try raising them by vegetative propagation like cuttings or planting tubers. Sugarcane can be raised by cuttings. (Refer to Unit IX, Class VI, Concept 6 a.)

Major Concept 3. Plants need certain mineral salts for healthy growth.

Concept 3-a, b (p. 100) : (a) Certain minerals are needed in larger quantities : namely, compounds of nitrogen, phosphorus and potassium.
(b) Certain minerals are needed in traces only : namely, compounds of iron, manganese, magnesium, boron and zinc.

1. Take five clear bottles as shown in the picture. (Fig. IX.21.) Prepare a culture (nutrient) solution as per formula given in Table IX–2. This solution contains all the minerals necessary for plant growth.

Now prepare a similar solution with no nitrogen or nitrate in it. Pour this up to three-fourths capacity in bottle 1.

Prepare another solution, this time eliminating the phosphate, and pour it in bottle 2.

Prepare a solution with no potash (potassium salts) and pour this in bottle 3.

Prepare another solution without the iron salt and pour this in bottle 4. In bottle 5 pour the original solution with all salts in solution.

Germinate a few paddy seeds separately and allow them to grow to a small extent. Take out these seedlings without injuring their roots, and wash their roots. Select equal-sized seedlings and place one in each bottle as shown in Fig. IX.21.

If the seedlings do not stand erect, they can be supported by means of slotted cardboards at the top of the bottle. Cover the bottle with black paper, to prevent light from reaching the roots. Set the bottles in the open sunlight for a few days and watch. If the levels of the solutions go down, add a little of the respective solutions to the bottles. Note the growth of the seedlings in each bottle. Which of them grows well and which of them look different? Note the appearance of the plant in bottle 1. What is the size of the leaf and its colour?

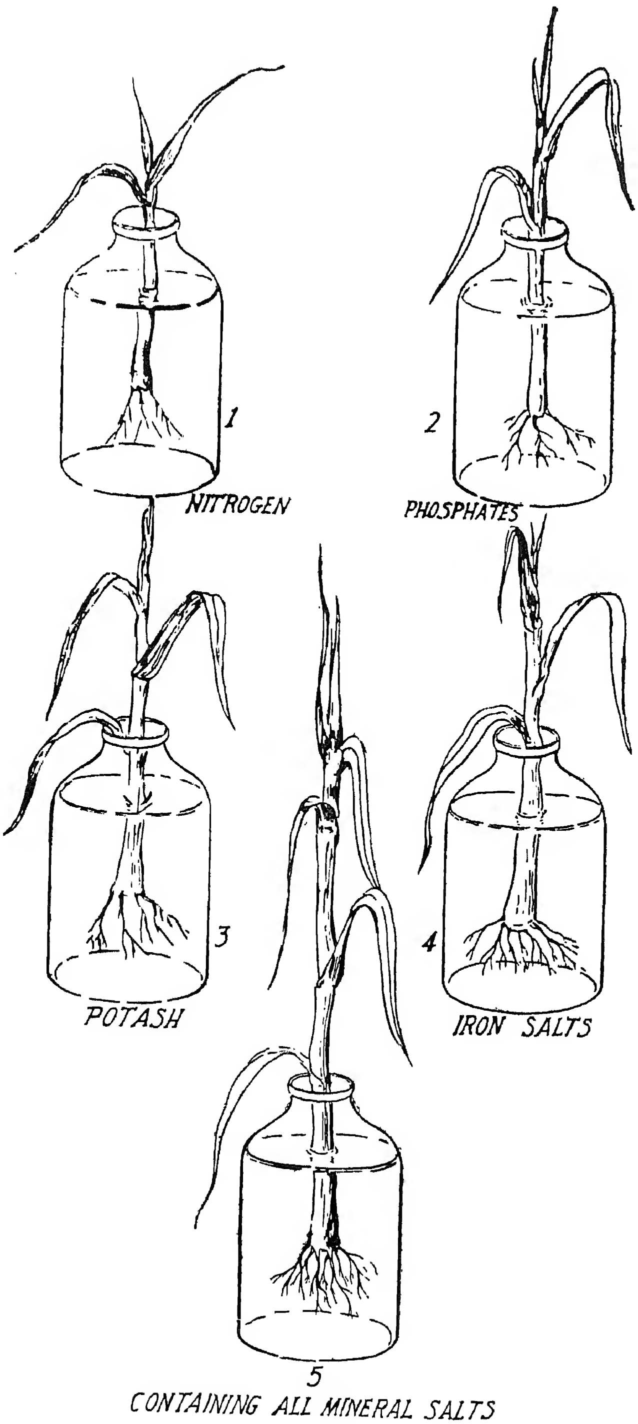


Fig. IX. 21. Plants need minerals.
Bottles 1—4 lack the minerals indicated. Bottle 5 contains all necessary minerals.

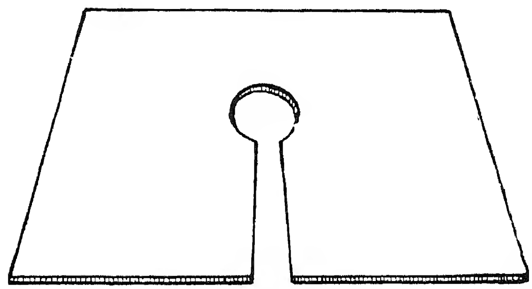


Fig. IX. 22. Cardboard support for seedlings.

Bottle 2. Are the plants strong ? Note whether the leaves are thin and few.

Bottle 3. How does this compare with the plants in 1 and 2?

Bottle 4. What is the colour of the leaves?

Bottle 5. Are the plants normal?

TABLE IX-2. NORMAL CULTURE SOLUTION (KNOP'S)

$Ca(NO_3)_2 \cdot 4H_2O$	Calcium nitrate	0.8 gm.
KNO_3	Potassium nitrate	0.2 gm.
KH_2PO_4	Potassium acid phosphate	0.2 gm.
$MgSO_4 \cdot 7H_2O$	Magnesium sulphate	0.2 gm.
$FePO_4$	Iron phosphate	trace.
Water	.. ..	1000 ml.

In order to support good growth in plants, soil must contain a supply of all the major and minor elements essential for plant growth. The predominant minerals in soils are, however, oxides

and related complex combinations of silicon and aluminium materials which do not contribute directly to the nutrition of the plant. Silicon makes up about 75 per cent of the soil.

Plant nutrients constitute a relatively small proportion of the total weight or bulk of even very fertile soil. The essential elements needed by plants are listed below. They are listed in order of percentage and weight per acre of good soil according to figures in *Introduction to Soil Science* by Geoffrey W. Leeper.

TABLE IX—3. NUTRIENTS NEEDED FOR PLANT GROWTH

Essential element	Percentage in soil	Amount (lb./acre)
Iron (Fe)	3.5	70,000
Potassium (K)	1.5	30,000
Calcium (Ca)	0.5	10,000
Magnesium (Mg)	0.4	8,000
Nitrogen (N)	0.1	2,000
Phosphorus (P)	0.06	1,200
Sulphur (S)	0.05	1,000
Manganese (Mn)	0.05	1,000
Boron (B)	0.002	40
Zinc (Zn)	0.001	20
Copper (Cu)	0.005	5
Molybdenum (Mo)	0.0001	2

TABLE IX—4. NUTRIENTS AND THEIR EFFECT ON PLANT GROWTH

Nutrients provided	*Effect on Plant Growth*
Complete solution	Plant healthy looking; solid green leaves; stem slightly thinner and leaves smaller than those grown outdoors.
No magnesium	Long slender stems; leaves spotted yellow to light green; roots thick and short.
No calcium	Slender stems; leaves spotted green and yellow between veins; browning at tips of rootlets; few rootlets.
No nitrogen	Short, slender stems; pale-green to yellow-green leaves; roots very long and slender; rootlets almost absent.
No potassium	Long, slender stems; slight yellow-green leaf colour; leaves curling and drying along margins of older leaves.
No iron	Plants tall and slender; leaves and stems spotted yellow and drying out; roots short, stubby; very short rootlets.
No phosphorus	Stem tall and slender, otherwise no noticeable symptoms; fruit will be incomplete when it develops.

2. Select a patch of sandy soil with grass growing on it. In the patch of grass, select that part (a square metre) where the grass looks paler than the rest of the area. Mark off a section in this pale area and evenly scatter about 10 to 30 gm. of sodium nitrate over this area. Water this part immediately so that the nitrate can soak down in a solution. Watch for the next two weeks. Compare the treated area with the untreated one. How does the grass in the treated one look? Is it greener and does it grow faster than in the untreated area? Is there more of it? Fertilizers serve two purposes: to make good any serious deficiencies in the soil; and to raise the level of crop production where no deficiencies exist.

Major Concept 4. Leguminous plants increase the nitrogen content of the soils.

Concept 4-a (p. 100): Leguminous plants develop certain structures on their roots, called 'nodules.'

To show that leguminous plants develop nodules on their roots, dig out carefully with the roots intact any leguminous weed such as clover, *Tephrosia* or *Cassia*, or a small plant of any one of the pulses, like Bengal gram, green gram or black gram. Wash the roots in water and observe. Do you find the roots showing swellings or nodules? What is their structure? How are these useful to the plants on which they are found and to the soil in which the roots develop? (Refer to Fig. VIII.11.)

The nitrogen cycle is very complex. The following points are important.

1. Most living things cannot use nitrogen directly from the atmosphere.

2. Only a few kinds of bacteria can use nitrogen from the atmosphere. Some of these bacteria live in the soil; others live in nodules on the roots of leguminous plants. A few species of blue-green algae are also able to use atmospheric nitrogen.

3. Green plants can use only *fixed* nitrogen: that is, nitrogen and oxygen combined, or nitrogen and hydrogen combined, to make their proteins. Most other living things are dependent for their proteins on those made by green plants.

Concept 4-b (p. 100): These nodules contain bacteria which can convert atomospheric nitrogen into nitrogen compounds.

Take one or two nodules on a glass slide and place a drop of water over it. Gently crush the nodules with a clean glass rod or with the blunt clean end of a long or dissecting needle. Place a cover glass gently over the curshed nodule. Examine this under the high power of a microscope or better still under an oil immersion lens. Observe the thousands of bacteria. Can you now see why farmers grow leguminous plants as green manure crops for their soil.

To show that nitrogen-fixing bacteria enrich the soil and make plants grow better, take four small flower pots and sterilize them in a slow oven or an auto-clave. Add nitrogen-fixing bacteria (it can be obtained from any big Agricultural Research Station) to the soil in two pots. Add a few soaked clover seeds (Egyptian clover or *Trifolium alexandrinum*) to each of the four pots. Watch for a few days or weeks watering the pots each day. In which pots do you notice a more luxuriant growth of the clover plants?

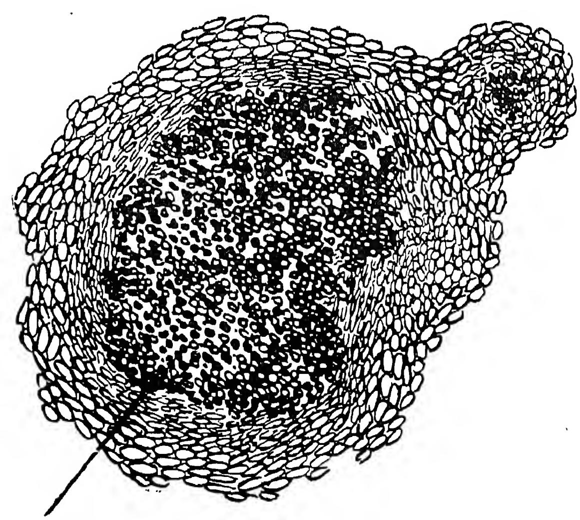


Fig. IX.23. Nitrogen-fixing bacteria in root nodules.

Concept 4-c (p. 100): When the leguminous plant dies, these nitrogen compounds are added to the soil.

Visit a field where the farmer is growing a leguminous crop. See how he ploughs the plant into the soil after harvesting the pods. Sometimes he grows leguminous plants only for ploughing them in later on. Relate this to the study of nitrogen and its use in producing healthy plants.

Concept 4-d (p. 100): Leguminous plants and seeds are rich in proteins and so are valued as food for man and other animals.

Make a study of your daily diet. List which foods contain starches, proteins, and fats. What foods do you take to obtain protein? Is *dhal* an important item in your diet? What is the value of this? Find other proteins in your diet.

Examine the fodder given to cattle. Apart from grass, what are the other plants given to them? Why are leguminous plants included?

Grow some gram and peas in the school garden and examine their growth and formation of fruits. Pull out one or two plants and examine the roots after washing them with water. Do you find any nodules where there may be nitrogen-fixing bacteria.

UNIT X

Animal Life

CLASS VI

EARTHWORM

Major Concept 1. The earthworm is a nocturnal animal living in moist soil.

Concept 1-a,b,c,d (p. 106) :(a) The earthworm seldom comes out in the day except in the rains when its hole is filled with water.
(b) The earthworm has a mouth and a muscular ringed body.
(c) It has no eyes or ears.
(d) It exchanges gases through its moist skin.

Observe closely some well turned up earth in a garden plot or flower bed. Do you find earthworms wriggling in the earth? Where did they come from? Look at another bed where the soil has not been turned up. Do you find earth worms here? Visit the same plot at night with a torch. Look for these earth worms. Do you find more worms moving about on the surface than you did during the day? Flood a bed with water and see whether the worms come out of the holes. How far below the surface do you find most of the worms? In the warm weather? In the rainy season?

Examine the front (anterior) tip of a worm and locate the mouth. Make a sketch of this part and the muscular body. What is the special feature you notice about it? Has it got eyes or ears? Can you say how it breathes? Why is its skin moist?

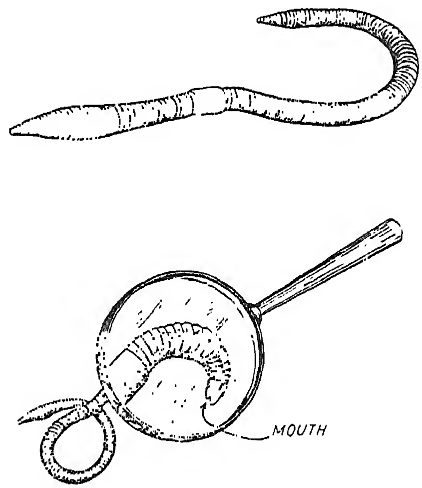


Fig. X.1. External view of earthworm with anterior (front) part magnified.

Major Concept 2. Its body parts are adapted to its food habits.

Concept 2-a,b (p. 107): (a) It has a pointed mouth by which it digs the earth to eat and burrow in its home.
(b) It eats earth and rotten animal and vegetable matter in the soil.

Examine the anterior part of the earthworm and its mouth. Has the worm any legs or arms? How does it burrow into the soil? Observe the use of the upper lip. It eats mud and burrows

deep. In loose soil the worms are able to make their burrows simply by pushing the soil away on all sides, but in compact soil, they actually eat their way through. Where is its food? Is it in the mud? It has no teeth, but it has a remarkable gizzard which grinds and pulverizes the soil it takes in.

Concept 2-c (p. 107): The excreta is passed out in the form of pellets at the opening of its burrow.

Look at the 'worm casts' left behind by earthworms, especially after a rain storm. Look about the hole for lumpy rings of 'castings'. What is the shape of the castings? What are they made of? They are the *excreta* passed out by the worm. Fill one flower pot with soil in which earthworms live and another with ordinary soil. Sow a few bean seeds in each and place the two pots in identical conditions of sunlight and air. Observe in which pot the seedlings grow faster and stronger.

Major Concept 3. The activities of the earthworm benefit the farmer.

Concept 3-a,b,c (p. 107): (a) Vast numbers of earthworms aerate the soil by their burrows.
(b) The soil is turned over by the earthworm.
(c) The excreta of the earthworm is a good manure.

Darwin called an earthworm a 'Little Ploughman.' By their burrowing, they bore holes into the soil. Air is let in which is good for the roots of plants. The burrowing turns up the soil. The 'casts' left behind by the worms are rich in organic material which makes good plant food.

To observe how soil is turned over by earthworms:

Obtain two wide-mouthed jars. Moisten some dark soil (loam or leaf mould) and some light coloured soil (sand). Make three distinct layers in each jar, light-dark-light or *vice versa*. Put the earthworms on top of the soil in one jar. Wrap the jar with a sheet of dark paper, which should help to lure the worms to tunnel towards the outside of the jar so that you can observe them. In a couple of days you should begin to see dark tunnels through the sand layer until eventually the soil in the jar is quite thoroughly mixed. Compare this jar with the jar without worms. Watch the soil pass through the earthworms as they tunnel through. If possible, watch a worm in its hole and note how it moves up to the top of the hole, and moves out in a circle in search of food. Be sure to replace the dark cover on the jar, when not watching the earthworms.

Earth worms may be kept in small wooden boxes. Place in the box 8—10 cm. of peat moss or rich soil. Keep the soil moist by dampening. Place a pad of about ten thicknesses of newspaper loosely on the surface and keep this quite damp. Keep the box in a dark or partially dark place. Feed the earthworms twice a week with bits of lettuce, damp cereal, or bread soaked in milk. Place the food on the surface of the soil or pot and cover the soil again with news paper.

FISH

Major Concept 1. The body parts of the fish are adapted for living in water.

Concept 1-a (p. 107): The body of a fish is streamlined and is suited for movement in water.

Look at the body of the fish. What is its shape? Observe a fish swimming in the school aquarium or a nearby pond. Does it appear to take much effort in swimming? It has a broad middle, but its front and hind ends are tapering. It cleaves the water as it moves along. The body is said to be streamlined. Do you know what this means? What else do you know that is streamlined? Draw a streamlined fish, a streamlined car, a streamlined jet plane.

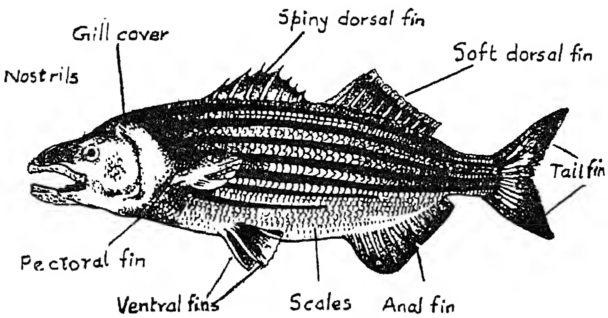


Fig. X.2. External view of fish.

Help the pupils in setting up an aquarium. This will stimulate them to observe, ask and answer questions. Proceed this way:

(1) Take an aquarium tank of 5 to 10 gallon capacity. See that it has a slate bottom, good quality glass sides and metal frames that do not rust. Check to see that the sides are well cemented so that it is water-tight. It is preferable to have the tank short and wide, so that a large amount of water surface is exposed to the air.

(2) Wash the tank thoroughly with salt water. *Do not* use soap or other detergents.

(3) Wash sand until the very fine silt that is often mixed with it is removed. If unwashed sand is used in aquaria, every time animals move along the bottom, they stir up this fine silt, making it difficult to observe them.

(4) Place this well-rinsed sand in the bottom of the tank to a depth of about two inches so that it slopes from the back to the front of the tank.

(5) Plant some water plants like *Vallisneria*, *Elodea*, *Hydrilla*, or *Sagittaria* in the sand, preferably in the deeper sand in the rear. Wash the plants thoroughly in salt-water before planting them. (4 oz. of salt to a gallon of water.) Place some washed gravel around the stems of the plants to anchor them.

(6) Place the tank where it will get plenty of light, but not direct sunlight. Too much sunlight will make algae grow more rapidly in the water and on the plants than is good for the aquarium.

(7) Take a pail of water and allow it to stand overnight, in order to allow disinfecting gases to escape. (Chlorine is usually added to city water.)

(8) Place a sheet of heavy paper over the plants and pour the water slowly on the paper. This will help to avoid disturbing the arrangement of the sand and plants. Fill until the water rises to within an inch of the top. Remove the paper.

(9) Wait for a day or two for the water to clear. Now place fish and other water animals in the tank. Select small minnows as they need less oxygen than larger ones.

(10) Finally, cover the tank with a glass to keep out the dust and reduce evaporation.

(11) *Do not overcrowd the tank.* The general rule is one inch of fish to one gallon of water. If plants grow too profusely, remove some of them. Snails help to clean up an aquarium. Water should be added regularly just sufficient to replace that which has evaporated.

Concept 1-b (p. 107): The gills of fish are adapted for breathing in water.

Take a fish. Look a little behind the snout. Do you find two flaps on the sides of the fish's head? These are the *gill covers.* Remove the flaps and observe the *gills* beneath.

How does a fish breathe? As it swims, watch how it opens its mouth and lets water in. When it closes its mouth, the water is forced past the gills and out through the gill openings. How does this passage of water over the gills help the fish to get its oxygen? The skin on the gills is very thin and there is blood close to the surface. Oxygen is able to go from the water through the thin skin. The blood carries the oxygen to all parts of the fish's body.

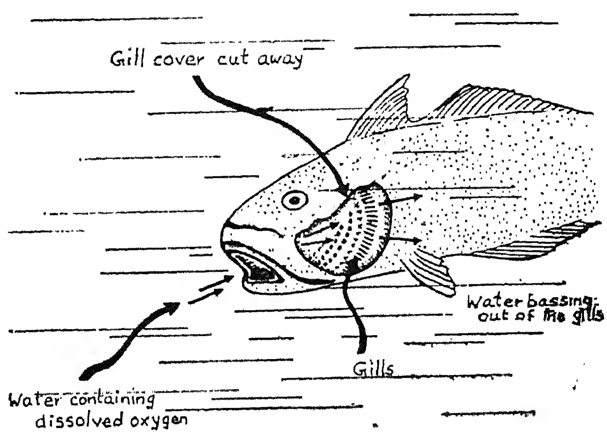


Fig. X.3. In the gills of the fish, oxygen is absorbed from the water and taken into the circulatory system.

Concept 1-c (p. 107): The mouth parts of a fish are suited to its food habits.

Look at a picture book of fishes or visit an aquarium if there is one in the neighbourhood and watch the different fishes.

The fish has a big mouth in proportion to its size and it swallows its food whole. Its jaws are equipped with comb-like structures (recurved teeth) which meet and slightly overlap when the jaws are closed. You have no doubt observed that the fish swims quickly through the water with its jaws wide open until its mouth is filled with water. Explain how these structures enable fish to get food. Some fishes have an excellent sense of touch, this being aided by sensitive feelers (barbels) near the mouth.

Some fishes swim faster than the others. Thus they can chase their food and also escape their enemies.

The flounders are bottom-dwellers. They swim on their sides and eat the bottom-dwelling worms and other living things.

The sword-fish has a long sharp 'sword like' a beak, by which it can protect itself and also kill other fish for food.

The sawfish has a long flat nose with sharp, hard teeth on the edges. It swims into a school of fish and cuts several badly by swinging its head. Then it eats the injured ones. Most ray-fish have poisonous stingers located part way down on their whip-like tail. These are sharply toothed, causing painful wounds.

The shark remora clings to the shark by means of suction cups on the upper fin, following it closely wherever it goes. When the shark feeds, the remora loosens itself and eats some of the scraps.

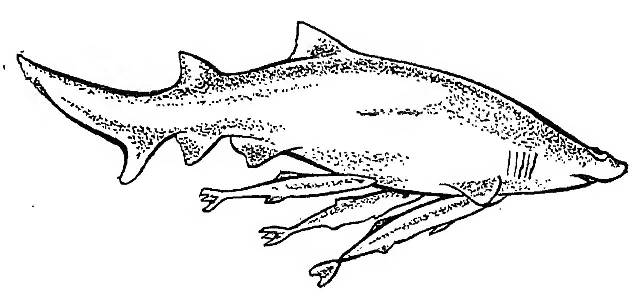


Fig. X.4 Shark remora clinging to a shark.

Find out other ways in which fish are adapted to their environments.

Major Concept 2. Fish are a source of food to man and animals.

Concept 2-a,d (p. 107) : (a) Fish is a good source of animal protein food for man.
(d) Cod and shark liver oils are good sources of vitamins A and D.

Look at the comparative food values given in Table X. 1. Pick out the food rich in proteins and vitamin A. You will be able to see why fish is recommended as a good source of *protein.* Test fish for protein. Take a piece in a test tube. Add about 10 cc. of nitric acid and heat gently. A yellow colour appears. Pour off the nitric acid. Cool the piece and add a little ammonia water. The piece of fish will turn bright orange. This colour shows that fish are rich in protein.

Visit a sea shore if one is nearby or a river, or lake or pond. Watch the catch of fish the fisherman brings back.

Fish are also rich in vitamins A and D. What part of fish is rich in vitamins A and D ? When a baby is weak and sick, doctors may advise that cod-liver oil should be taken. Shark and cod-livers are rich in vitamins A and D.

TABLE X.1. QUANTITIES OF PROTEINS AND VITAMINS PRESENT IN 100 CALORIE PORTIONS OF SOME FOODS.*

Food	Measure	Proteins	Vitamin A.	Vitamin C.	Vitamin B.
White bread	2 slices	1.6	—	—	—
Whole milk	5—8 cups	2.2	1.7	0.9	3.7
Banana	1 medium	0.6	1.7	3.2	0.7
Potato	1 medium	1.1	0.3	1.0	0.8
Spinach chopped, steamed	2½ cups	3.5	500.0	28.0	16.0
Butter	1	—	3.3	—	—
Eggs	1 large	3.9	6.1	—	2.7
Liver	Avg. serving	6.8	35.0	2.4	19.1
Fish	Avg. serving	5.8	0.8	—	5.4

* Each unit, (share) represents one thirtieth of a man's daily requirement of a food nutrient. Thus an average serving of liver furnishes 6.8 shares of protein, about ¼ of a man's daily requirement; 35 shares of vitamin A, more than the daily requirement, 2.4 shares of vitamin C, about 1/12th the daily requirement, and 19.1 shares of vitamin B, more than half the daily requiremen t.

Concept 2-b (p. 107) : Fish are a source of food for some birds and water animals.

Visit a big pond, lake or sea. Watch the birds flying low, almost above the surface of the water. From time to time they swoop down, dip their beaks into the water and rise up again. Watch how they catch fish in their bills.

Concept 2-c (p. 107) : Fish waste is a good manure.

Farmers often use organic wastes as manures. Ask any farmer and find out whether he uses fish waste as *manure*. In what respect is this better than any other organic manure? It contains certain trace elements from the sea such as iodine which may be deficient in certain soils.

If you have an aquarium at home or school, use some of the watery waste, after cleaning the aquarium, as a fertilizer in growing school plants. Set up an experiment to test the value of fish waste in growing plants.

Frog

Major Concept 1. The adult frog lives both on land and in water.

Concept 1-a (p. 107) : It can use its limbs to jump on land and also to swim in water.

Observe frogs in a pond. See how they live as easily in water as they do on land. Such animals are called *amphibians*. Take a fish out of the water and place it on land. How long can it live? Put the fish back into the water quickly after observation for it cannot live long on land. Take a frog out of water and place it on land. What happens?

Try to catch a frog, on land. It is not easy. It leaps off, out of your reach. It takes big, long leaps. Catch hold of a frog and examine its hind legs. Which are more powerful, the hind legs or the fore limbs? Observe the joints in the hind legs. What gives the frog that extra force in its hop? Find out about other jumping animals; the kangaroo, grasshopper, and flea.

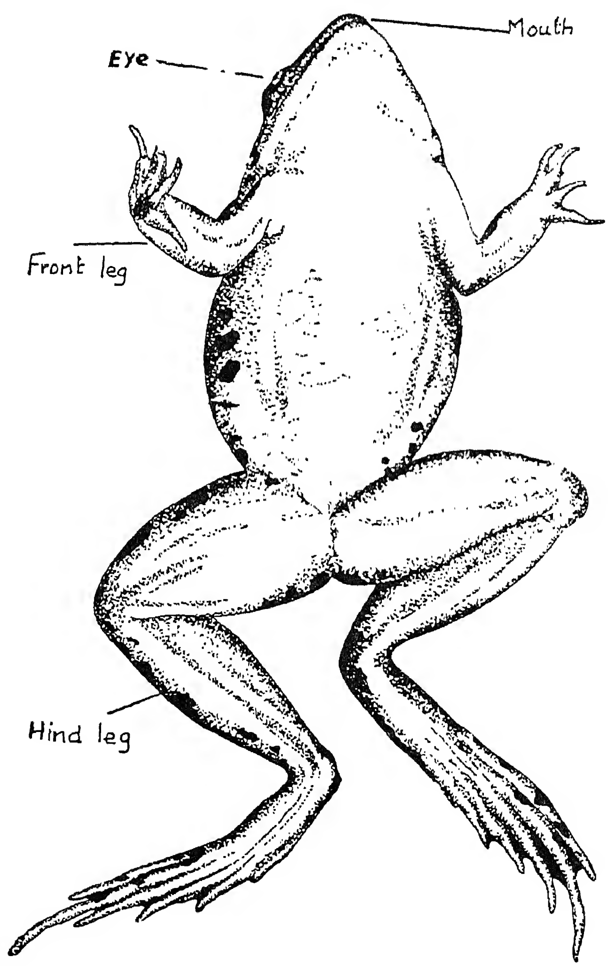


Fig.X.5. The frog.

Examine the ends of the hind and front feet. Observe the webbed feet, which are more pronounced in the hind legs. How do the folds of skin between the toes assist the frog in swimming?

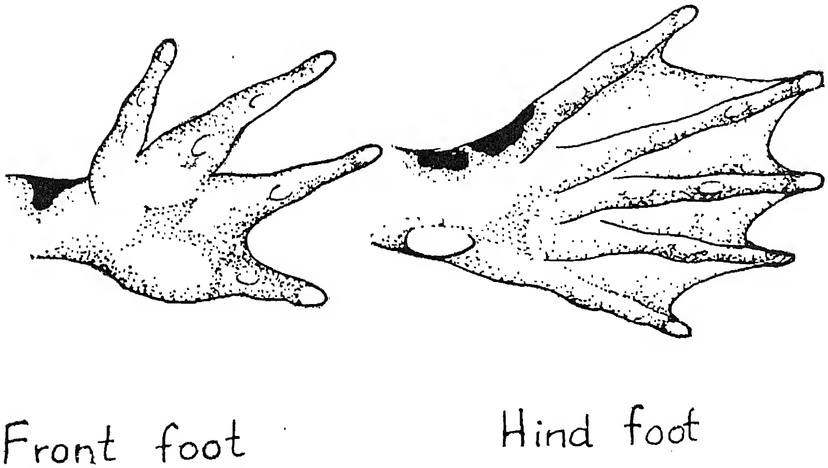


Fig. X.6. Front and hind feet cf frog.

Concept 1-b (**p. 107**)**:** It feeds on insects which are found mostly on land.

Watch a frog catching an insect. See how quickly its lightning-quick tongue shoots out and catches the prey. Open the mouth of a frog that has been killed by chloroform and observe its tongue. The frog's tongue is attached at the front of its mouth so that it is easily thrust out. You have to watch very closely to see this action. The frog's tongue is also very sticky. This makes it difficult for an insect to escape, once it comes in contact with the tongue.

You can also observe the frog's tongue by dangling a piece of lean meat or liver on a fine, unknotted thread in front of a live frog.

Observe and record the various kinds of animals that the frog eats. Do you think that the frog helps the gardener in getting rid of many garden enemies?

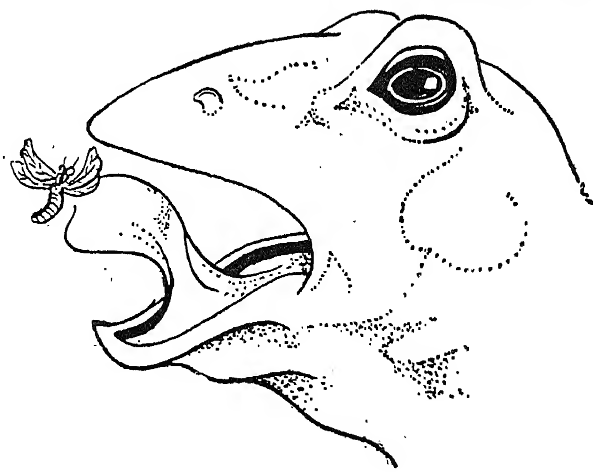


Fig. X 7. Frog catching an insect.

Concept 1-c (**p. 107**)**:** It jumps into water for protection.

Observe the behaviour of a frog on land. Try to chase it. How does it escape its enemies? The adult frog prefers to live near the water.

Concept 1-d (**p. 107**)**:** It breathes air into its lungs by taking air into its mouth through its nostrils and swallowing it. It also exchanges gases through its moist skin.

3. When on land, how does the frog breathe? Have you ever wondered how the frog, which is an air-breather, is able to stay under water? It is because of skin respiration. Feel the skin of a frog. It is thin and richly supplied with blood vessels. While under water, dissolved oxygen passes through the skin to the blood, and carbon dioxide is given off. This supplies enough oxygen so long as the frog is quiet. When it is more active, such as when it swims, it comes up to the surface to breathe air. The frog's skin is usually coated with a slippery mucuos which is secreted by glands in the skin and oozes through the pores in the skin.

Major Concept 2. The eggs develop through a series of changes into the adult frogs.

Concept 2-a, b, c, d, e, f, g (p. 108) :
(a) It lays eggs in water.
(b) The eggs hatch into tiny tadpoles.
(c) The tadpole swims by its tail.
(d) It exchanges gases through its skin and gills.
(e) It feeds on tiny vegetable matter in water and grows rapidly.
(f) It develops legs and loses its tail.
(g) As it becomes an adult, its feeding, breathing and swimming habits change.

Observe a pond where frogs live. Notice the frothy white, mucilaginous masses floating on the surface. They are the *spawn*, or egg-masses, of the frog. The frogs lay their eggs in water.

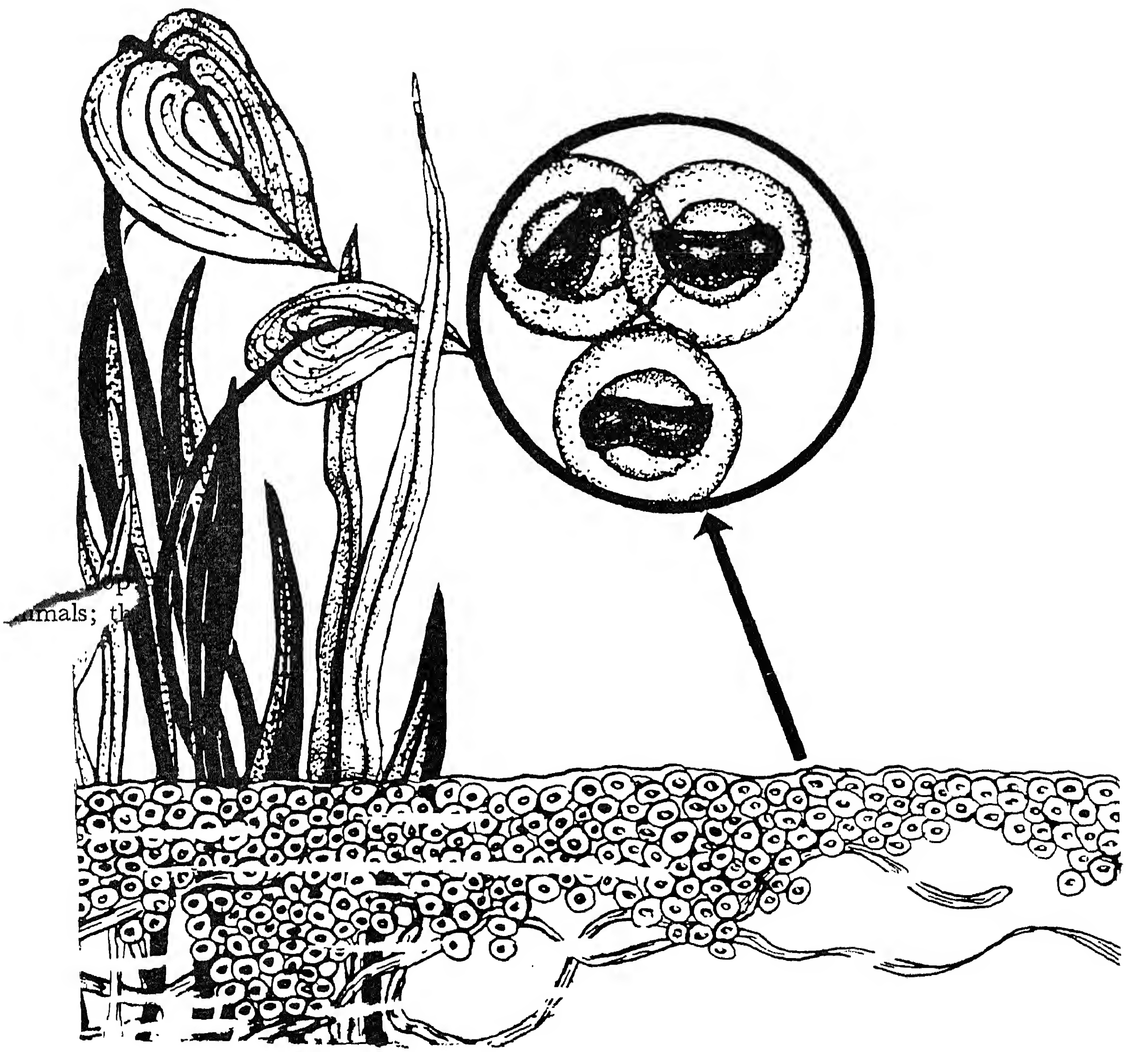


Fig. X.8. Eggs of frog.

Collect a few eggs in a jar of pond water and place the jar in a room near an aquarium. Wait until the temperature of the water in the jar is the same as that in the aquarium. Transfer the jar water with the spawn to the aquarium. Keep the aquarium clean and at an even temperature. Examine some of the eggs and note the layers of 'jelly' around each one. In a few days the eggs will hatch, the jelly will fall away, and out of them will come small little swimming animals. These are the tadpoles. See how different they look from the adult frog. They also differ from the adult frog in the way they breathe and eat. If there are too many tadpoles, remove some of them to prevent overcrowding.

Place a piece of rock in the aquarium so that a portion of it projects out of the water. The tadpoles will stay close to the rock. Note the changes that take place in the tadpoles from day to day and make your own chart to describe their development. Begin with the day the egg hatches and continue until the time the adult frog is formed. Compare your chart with Fig. X.9, which shows the *life cycle* of a frog.

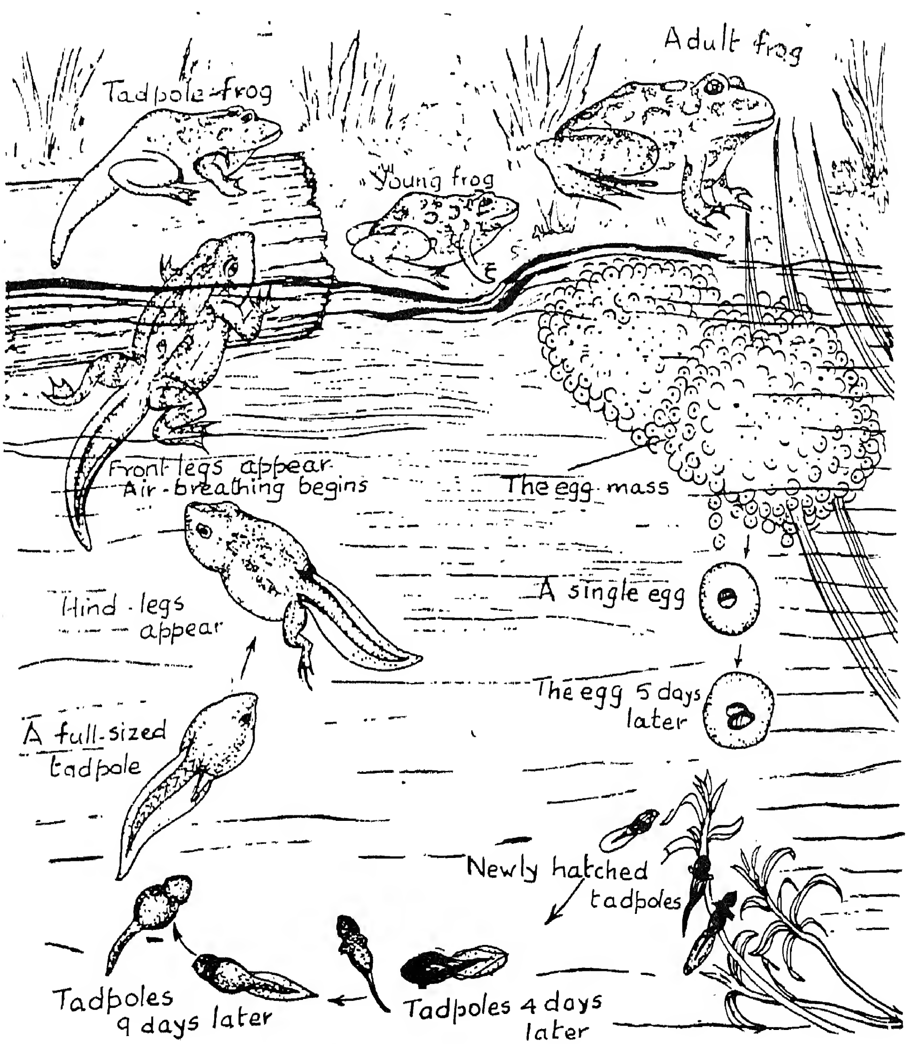


Fig. X.9. The life cycle of the frog.

Major Concept 1. The structure of the mouth is fitted to the food habits of the animal.

Concept 1-a,b,c,d,e (p. 108) :
(a) The cow and the horse do not possess canine teeth.
(b) The cow has cutting teeth on the lower jaw. The upper jaw has only a stiff gum. It feeds by wrapping its tongue around the grass and then cutting the grass with its lower teeth.
(c) The horse has cutting teeth on both jaws.
(d) The dog and the cat have well developed canine teeth.
(e) The plant-eating animals have well-developed molars.

To find out how the mouths of certain animals are fitted to their food habits, examine pictures of the head of a cow, horse, dog and cat. Observe these animals when they eat. Note their teeth. You can visit a museum and observe the skulls of these animals to see their jaws and teeth. What differences do you find? The cow and the horse do not have canine teeth. The *incisors* are the cutting teeth. Examine both jaws of the cow as well as those of the horse. The horse has cutting teeth on both jaws while the cow has them only on the lower jaw. The dog and the cat have *canine* teeth. Look at your own teeth in a mirror. The four front teeth on the upper and lower jaws are especially shaped for cutting. The next tooth resembles a dog's tooth (canine). There are four canine (cuspid) teeth. They are for tearing food. The back teeth pulverize food so that it can be easily made liquid. What differences will you find among the food habits of dogs, cats and man? Which of them are *herbivorous* (eating plants only) and which eat meat ? Which eat both plants and animals? What is the particular use of the canine teeth?

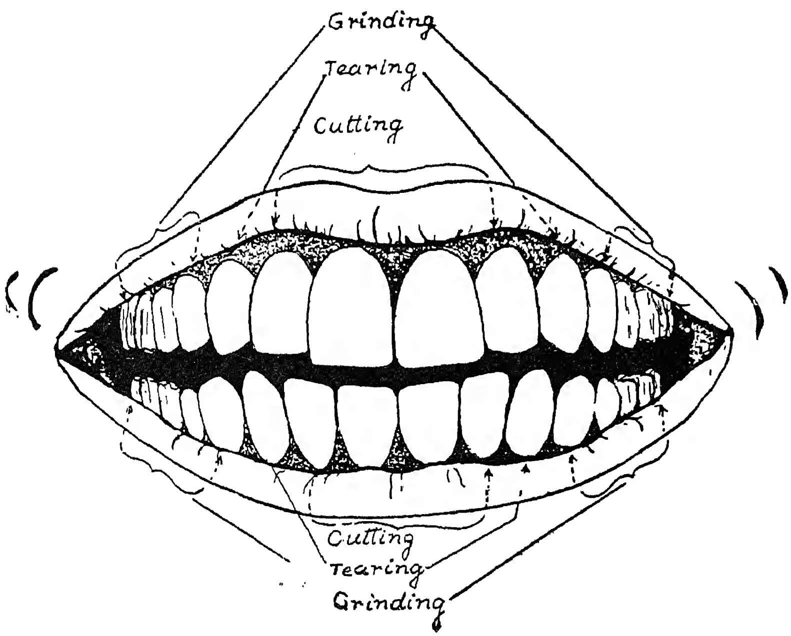


Fig. X.10 a. Teeth in Man.

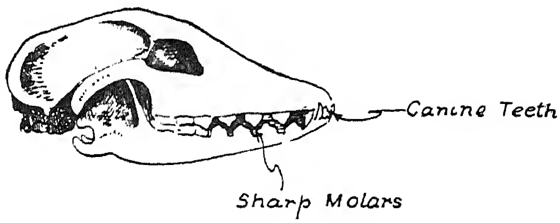


Fig. X.10 b. Dog's molar teeth are sharp.

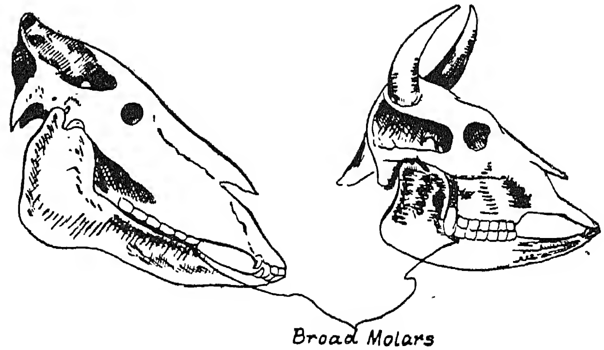


Fig. X.10 c. Teeth of cow and horse.

Examine the molars (shown in Fig. X a-c). Note the broad grinding surfaces. These are well developed in the horse and the cow, but not in the dog and the cat. Why are molars necessary for the cow and the horse and not for the cat and the dog? Note that the molars in the dog are sharp. How do you use your molars?

Major Concept 2. The digestive organs of herbivorous animals are adapted to their food habits.

Concept 2-a, b (p. 108): (a) The herbivorous animals have a comparatively long intestine in proportion to their body length.
(b) Some herbivorous animals have a pseudo-stomach in which they store food when swallowed then later chew the cud.

Observe a cow grazing. See how she stops now and again to chew the material she has grazed. When cows return from grazing and are at rest, see how their jaws are busy working. They are said to 'chew the cud.' What is meant by this term?

Look at this picture of the digestive system of a cow. Of what advantage are these *pseudo-stomachs?*

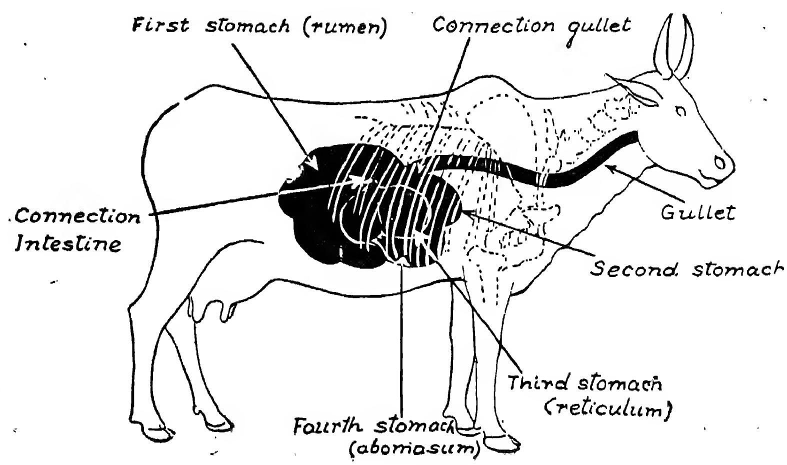
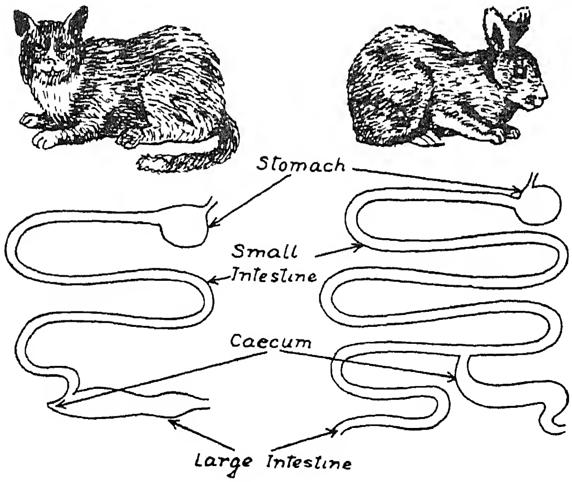


Fig. X.11. Digestive system of the cow



Look at the picture of the cat and rabbit given here, with their digestive tracts drawn to scale. What is the food that a cat takes? The cat is a flesh-eating, or *carnivorous*, animal. What kind of a feeder is a rabbit? Compare the two intestinal tracts. Which animal has a longer one? The pictures of the cat and the rabbit shown here appear to be of the same size, yet the rabbit has a longer digestive tract. Why? The rabbit is a herbivorous animal. It eats only plants. The caecum is located at the beginning of the large intestine and is closed at one end? Of what use is it?

Fig. X.12. Digestive tracts of cat and rabbit.

Major Concept 3. Reptiles crawl along the ground with or without limbs.

Concept 3-a,b,c,d (p. 108,109):
(a) Reptiles are cold blooded vertebrate animals.
(b) Common lizards, crocodiles and tortoises crawl with the help of four limbs.
(c) Snakes crawl without any limbs by the movement of body muscles, ribs and scales.
(d) Reptiles usually feed on other animals.

Reptiles include not only snakes, but turtles tortoises, lizards, crocodiles, alligators and others. Their bodies are covered with *scales*.

To learn more about reptiles:

a. Handle a live lizard or a chameleon. Do you find them cold or warm? Touch the body of a cat or a dog. How do they feel? Why are lizards called *cold-blooded* animals? What will happen to a lizard's body temperature on hot sand? If the air were cold, how would a lizard feel to touch? Do you think the term cold-blooded is an accurate one? Why not? The body temperature of these animals vary with the temperature of the environment.

b. Watch common lizards, tortoises and crocodiles if you can observe them at a safe distance. How many legs do each of these animals have? Do they move straight or do they wriggle ahead? Watch how some lizards are able to chase insects along the walls and ceilings of rooms. How do they do this? Examine their toes.

c. Have you observed the movement of a snake? Next time you find a snake-charmer, ask him to show you his snakes. Do they have legs? How do they move? How do they crawl without the help of legs? (See Fig. X.13, ventral scales.) The most common method of crawling is by pushing each body curve against irregularities on the ground. On a completely smooth surface snakes make little progress forward. Notice the hard plates, or scales on the underside of the snake. How can these help in crawling? The snake has

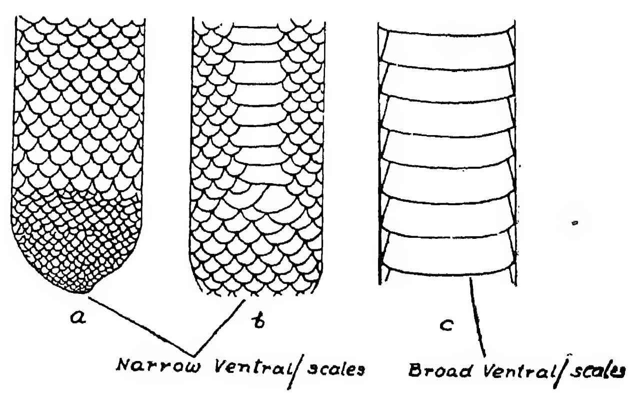


Fig. X.13. Ventral scales of different snakes.

several hundred vertebrae in its spinal column and to each vertebra is attached a pair of ribs which at the free end are fastened by muscles to the ventral scales. This body plan permits the s ake to move along on the rough ground and also allows large prey to be swallowed and moved through the body. It has been said that snakes 'walk on their ribs'. Can you explain this?

If you are certain that a snake is not poisonous, you can examine the ventral scales, that is, you can turn it on its back and examine the belly. If the scales there are broad, fully extending across the belly, the snake may be poisonous. If the scales are narrow and not well marked off, the snake is non-poisonous. See the books listed in the bibliography for authoritative information on snakes.

If possible vi it a local museum or a school or college to study snake specimens they exhibit there.

d. Watch a lizard (house lizard) and see how it catches moths and other insects. Does it take any other kind of food? Do reptiles feed on plants? Have you watched a snake swallow a rodent or a frog?

Major Concept 4. Snakes form a separate group of reptiles.

Concept 4-a (p. 109): Certain snakes are poisonous. They can be distinguished from non-poisonous snakes by certain characteristic features.

To find out about snakes, take every opportunity to observe their behaviour, but be certain you learn to distinguish the poisonous ones from the non-poisonous.

The chief poisonous snakes of our country are the cobras, the krait, the pit vipers, the pitless vipers such as the horned viper and the Russell's viper and sea snakes. Sea snakes have a flat, fin-like tail while land snakes have a round cylindrical tail. Sea snakes have nostrils on top of the snouts so they can breathe while swimming. The scales on the heads of most snakes are longer than they are wide. Such snakes are called *shields*. One ach snake these are arranged in a certain pattern. Each species of snake has a characteristic arrangement of scales and shields. Such patterns aid in identifying snakes.

If the head has scales and not shields, the snake is a viper and poisonous. Some vipers like pit vipers have a *pit* between the eyes and the nasals. The other vipers without pits are poisonous too, such as the horned viper, the Russell's viper, and the little Indian viper. The eye of the pit vipers has a vertical pupil, and not a circular one.

If the head is covered with shields it may be a cobra or a krait. Experience will tell you how to distinguish snakes. Guidance from experts

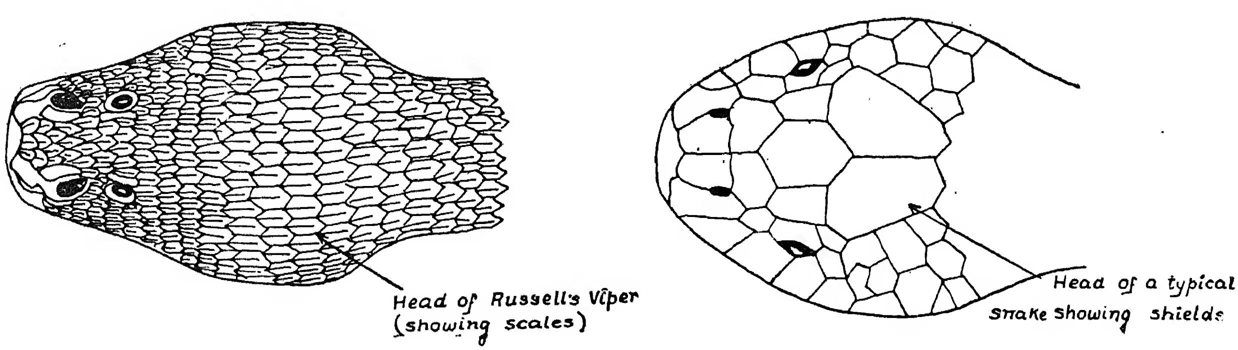


Fig. X.14 a,b. Comparison of heads of snakes with scales and shields.

will help. Look at the peculiar characteristic in the head of the cobra shown here.

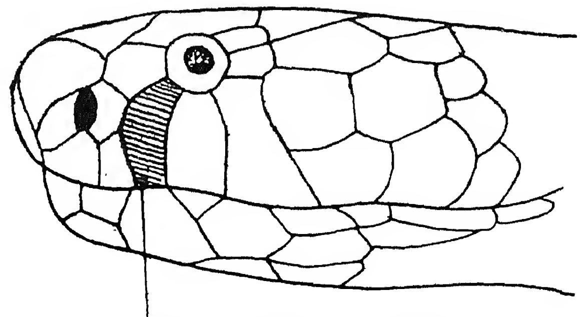


Fig. X.14 c. Side view of cobra head showing the large third upper lip shield.

Concept 4-b (p. 109): The snakes have an elastic binding of their jaws which enables them to swallow a whole animal by stretching the jaws.

Have you seen a snake swallowing a frog? The frog is so big in size compared to the size of the snake's head. How then does the snake swallow this frog whole? Examine the skull of a snake, if one is available. Note the way in which the lower jaw is attached. See how it is attached not directly to the skull but to a separate bone, which acts as a hinge. Examine the lower jaw. Each side of the snake's lower jaw moves separately. The structure of the mouth and skull are so constructed that the movable parts can be greatly stretched. This is of assistance because snakes swallow their food whole, eating rodents and others reptiles.

Concept 4-c (p. 109): The tongue of the snake is used as a sense organ.

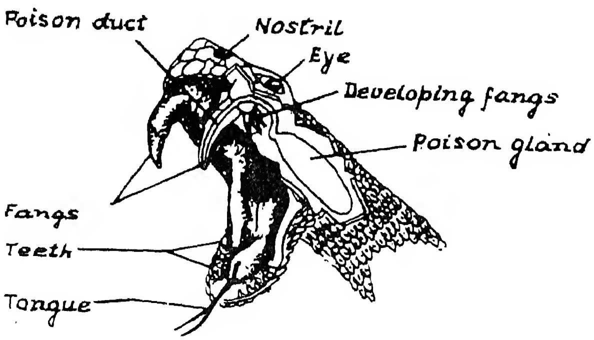


Fig. X.15. Tongue and fangs of a poisonous snake.

What is the shape of the tongue? Where is it fixed? When a snake is prowling, its tongue is put out rapidly and withdrawn several times. The snake's long forked tongue is harmless. The tongue is used to sense things. How does a snake 'hear'? Snakes have no external hearing apparatus, but can hear through solids such as vibrations through the ground. They can see well at night.

Concept 4-d (p. 109): The poison of a poisonous snake is injected by a pair of grooved or hollow fangs which receive the poison from the poison glands.

Note in Fig. X.15 the modified head structure for poisoning and swallowing.

Where is the poison located in a posionous snake and how does it inject this into the body of its victim? When a snake has opened its mouth, do you see two long pointed teeth? What are these? See the figures given here and trace the poison from the gland to the *fangs*.

Concept 4-e (p. 109): The bite of a poisonous snake may be fatal and requires immediate first aid and treatment.

The bite of a poisonous snake can be fatal. What should you do as first aid and treatment in such cases? (See Unit IV on Safety and First Aid, Class VII, development of Concept 2a.)

The first thing to be done is to keep calm and not get panicky. If the symptoms are not serious, apply a constricting band made of a piece of cloth, a cord or a necktie (tourniquet) between the bite and the heart, and go at once to doctor. It is dangerous to leave a tourniquet on for a long time. Do not make the patient walk. He should be carried. If the swelling is rapid and the pain is too intense, do this: sterilize the bitten spot with spirit and with a sharp blade, sterilized in spirit, cut a small incision 1/4 cm. × 1/4 cm. and 1/4 cm. deep. Suck with the mouth or apply suction by a rubber ball. Do not suck too rapidly. The mouth of the sucker should have no cut or wound which would allow poison to enter his blood stream. Get the patient to a doctor at once.

Reproduction

Major Concept 1. Birds, reptiles, amphibians, fishes, insects and many other animals lay eggs.

Name all animals you know which lay eggs from which young are hatched. Place them in groups of birds, reptiles, amphibians, fish, insects. Take one animal for study. Find out where the eggs are laid, how long they take for hatching, and what care the young are given. Are there any animals in these groups that do not lay eggs, but bring forth their young alive? Find out about egg-laying of fish like the salmon, theeli.

Concept 1-a (p. 109): A fertilized egg is the first stage in the process of reproduction.

How does a young one start its life? When a cell divides it becomes two; again after division four, and so on, till you get the multicellular body of most animals. Suppose you trace back, where will it lead? It will lead you to a single cell—the *fertilized egg*.

Concept 1-b (p. 109) : The fertilized egg develops into an embryo.

Find a fertile hen's egg. Eggs from yards where there are roosters are usually fertile. Take such an egg from a 'setting hen.' Open it and see the yellow yolk of it. Do you see any structure (embryo) on it? Does it look like the young chick? Examine an egg which is not fertilized. Does the yolk show any structure like the chick? If you look carefully at the the fertilized egg, you may see a whitish speck, called 'the germ spot'. This grows day by day into the structure which becomes the chick. Study Fig. X.16.

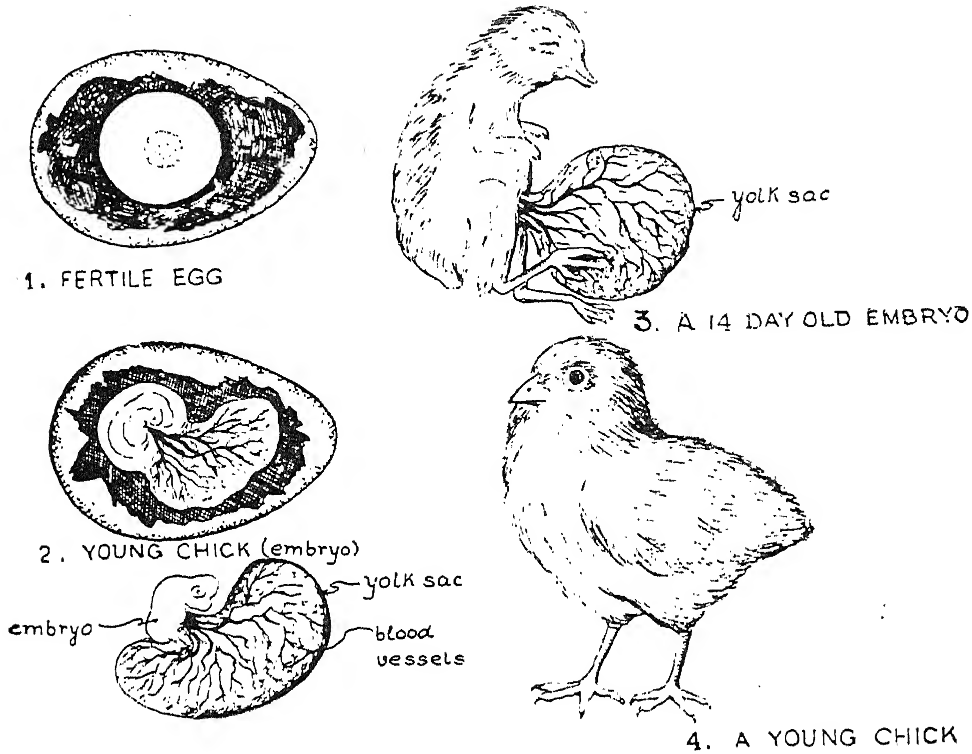


Fig. X.16. Fertilized hen's egg and stages in the development of the chick.

Concept 1-c (p. 109) : An egg contains food material for the growth of the embryo.

How does the young embryo inside the egg get its food, as it grows? What is the purpose of the 'white of the egg'? Both the yolk (yellow) and the 'white of the egg' (albumen) are essential for the embryo's development. The protein of the albumen and the oils of the yolk are stored nourishment for the young embryo.

Concept 1-d (p. 109): The eggs of birds, reptiles and fish directly hatch into young ones.

Observe the way young ones are hatched from the eggs, in the case of the hen, a sparrow, a lizard and a fish. Note how the young ones resemble the mother as soon as they come out of the egg.

Find a nest where birds are laying eggs. Visit the nest each day. Keep a record of the time it takes for the eggs to hatch, for the chicks to develop feathers, and for them to fly away. How do the parent birds feed the young? How often each day?

Concept 1-e (p. 109): The eggs of insects and amphibians hatch into larvae or tadpoles which again pass through several stages before the adult stage is reached.

Collect the eggs of moths or butterflies or if possible, collect a few *larvae* of the moth or butterfly, for example,—*Calotropis* or milk-weed plant often has green, yellow, and black speckled caterpillars (the larva form) of butterflies that live on it. Place a couple of these caterpillars in a cardboard box along with a few of the leaves of the plant on which you find them.

Pierce a few small holes in the sides and top of the box to let in air. If possible one side of the box can be replaced by a transparent sheet to enable you to observe. Watch the changes as the caterpillar goes into the *pupa* form and then as it becomes a moth or butterfly. Do all insects go through this larval stage? Observe the young of grasshoppers and note that the newly hatched ones resemble their parents.

Concept 1-f (p. 109) : Eggs may be hatched artificially in incubators.

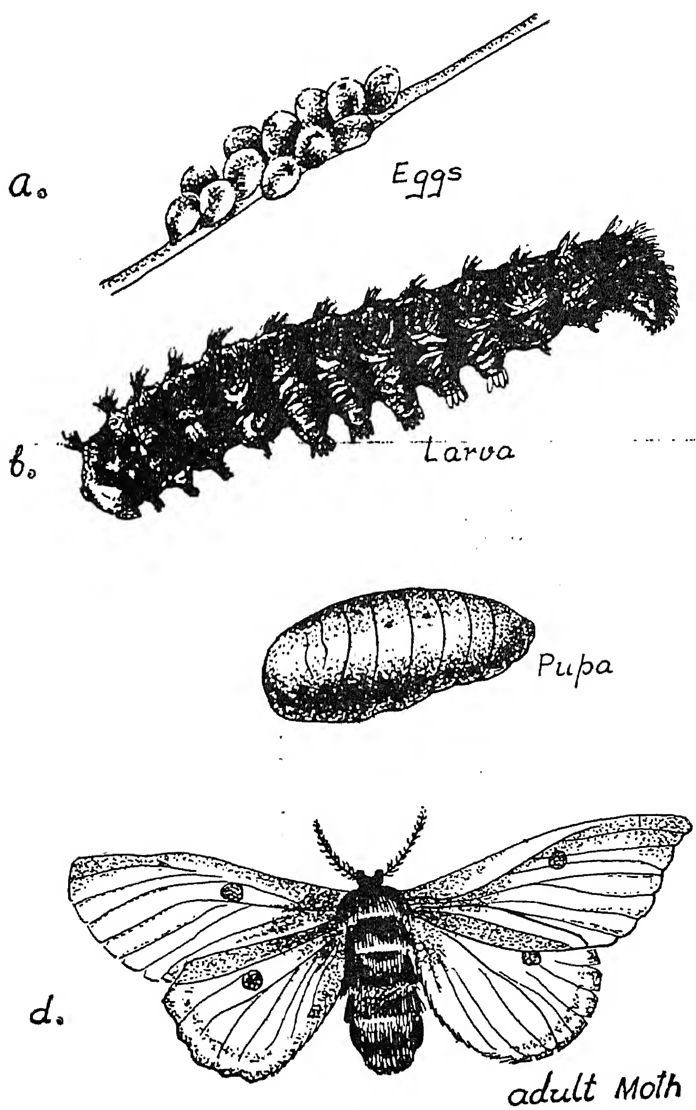


Fig. X.17. Changes in the life cycle of a moth. a. egg, b. larva. c. pupa. d. adult.

Observe how hens, sparrows and crows set in their nests over their eggs and keep them warm. How long does the mother bird sit? Visit a poultry farm, if one is nearby, and watch the eggs being incubated artificially in an incubator. Watch the eggs incubated for the full term (21 days) and see how the chicks come out.

If you have electricity in your classroom, try making a simple incubator. Secure two cardboard boxes, one to fit inside the other. You should place newspaper between them to act as an insulator. Cut one end from the small box and cut a window about 15 cm. in a side of the larger box. Next cut a slit in the top of the smaller box and suspend an electric lamp in it. Have your cord attached to the lamp fairly long.

Be sure the open end of the smaller box fits against the window end of the larger box. Place a thermometer in the box so that you can read it through the window. Fit a glass plate over the window.

Temperature is very important in this experiment. Try out various sized electric bulbs and different amounts of newspaper between your boxes to maintain a constant temperature in the box 40°C. Place a small dish of water in the improvised incubator.

Secure a dozen fertile eggs and place them in the incubator. At different stages you may wish to take out one egg to study the development of the embryo. Most of the eggs should be left for full development for 21 days.

Major Concept 2. Mammals give birth to young ones which suck milk from their mother.

Concept 2-a (p. 109): The fertilized egg develops within the womb of the mother for some time.

All embryos develop from a single fertilized egg cell and grow through division and redivision into the form of the parent organism. A many-celled ball-shaped structure is formed which moves down the tube called the *oviduct* to the *womb* or *uterus* and becomes attached to the wall of the uterus. Here it continues to develop. A structure containing many blood vessels spreads over the inner lining of the uterus. This is called the *placenta*. A cord called the *umbilical cord* leads the placenta to the embryo. Study Table X.2 and Fig. X.18 for further information on periods of development of the embryo (*gestation period*) and the nourishing of the embryo.

You must have observed a cow or a bitch about to have a young one. How does it differ from an ordinary cow or bitch? The pregnant cow has its little calf developing inside. Only after being inside the mother for a period of time is the calf or puppy born. This period of time is called pregnancy. With the camel the period of pregnancy is 13 months. This period varies in different animals. Study the Table below.

TABLE. X.2. GROWING PERIOD OF VARIOUS MAMMALS

Animal	Gestation Period	Maturing Time	Life Span
Mouse	20—30 days	6—7 weeks	6 years
Rat	21 days	8—9 weeks	3 years
Rabbit	30—32 days	6—9 months	8 years
Guinea pig	9 weeks	7 months	7 years
Cat	8—9 weeks	1—2 years	12—23 years
Lion	16 weeks	6 years	30—40 years
Dog	9 weeks	10 months—2 years	15—30 years
Fox	60—62 days	18 months	13—14 years
Sheep	21—22 weeks	1 to $1\frac{1}{2}$ years	12—15 years
Pig	4 months	5 years	30 years
Cattle	9 months	2 years	30 years
Hippopotamus	8 months	2 years	30 years
Deer	10 months	$4\frac{1}{2}$ years	40 years
Camel	13 months	8 years	40 years
Horse	11 months	2—4 years	30—60 years
Elephant	20 months	30—35 years	100 years
Monkey (*Macacus*)	6 months	2 years	18 years
Man	270—280 days	20—25 years	75 years

Concept 2-b,c (p. 109,110): (b) A placentum carries food from the mother to the growing embryo.

(c) The young one after birth depends on its mother's milk for nourishment till it is able to find food independently.

1. How does the calf inside its mother's womb (uterus) get its food and nourishment? Look at the picture of a young embryo of a mammal inside the womb. See the connection between the layers of the wall of the embryo sac and the embryo itself. The two are connected by blood vessels. In the placenta, the blood of the embryo comes into close contact, but does not mingle, with the mother's blood. As blood from the embryo circulates through the placenta, it receives oxygen and dissolved food materials from the mother's blood. Waste materials are removed through the mother's blood stream.

2. Observe, when the opportunity comes, how the calf, the kitten and the puppy are suckled by the mother. How long does the mother suckle the young ones? Note the stage at which the young ones begin to find food independently. Keep a record of the period of infancy in various animals.

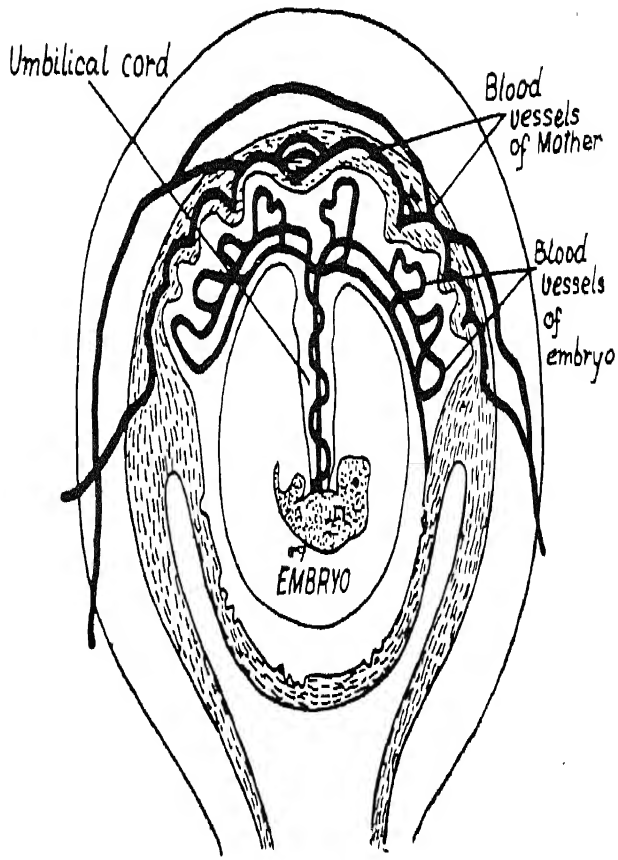


Fig. X.18. Uterus of a mammal containing embryo.

The fertilized egg grows within the body (in the womb or uterus) of the female parent until the yongone is born.

Major Concept 1. Animals can be classified broadly into vertebrates and invertebrates.

Concept 1-a,b (p. 110): (a) Animals which possess a backbone as a chief support to the skeleton are called 'vertebrates.'
(b) Animals without backbone are called 'invertebrates.'

Look at the figure given here of three animals which look alike: the earthworm, the eel and the snake. Do you find differences among them? Which of them has bones and which has no bones? Feel the earthworm. It is soft. It has no back bone. Have you touched a non-poisonous snake? Does it have a backbone?

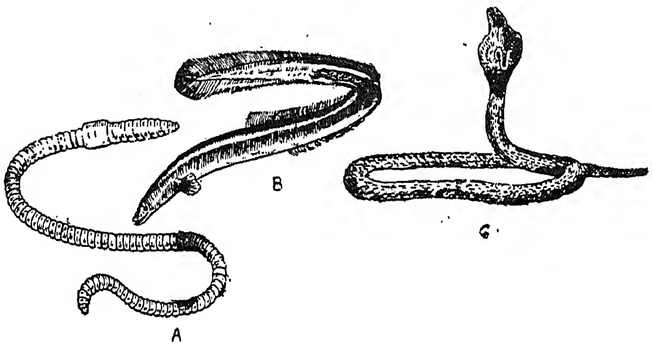


Fig. X.19. A—Earthworm, B—Eel and C—Snake (Cobra)

List all the animals you know in two columns, one containing those which have an internal skeleton and backbone (*veatebrates*) and those that do not have them (*invertebrates*).

Practice identifying the animals you see around you as vertebrates and invertebrates: for example, cow, bird, lizard, cat, mongoose, spider, crab, star fish.

Study Fig. X 20. How are these animals alike ? How do they differ?

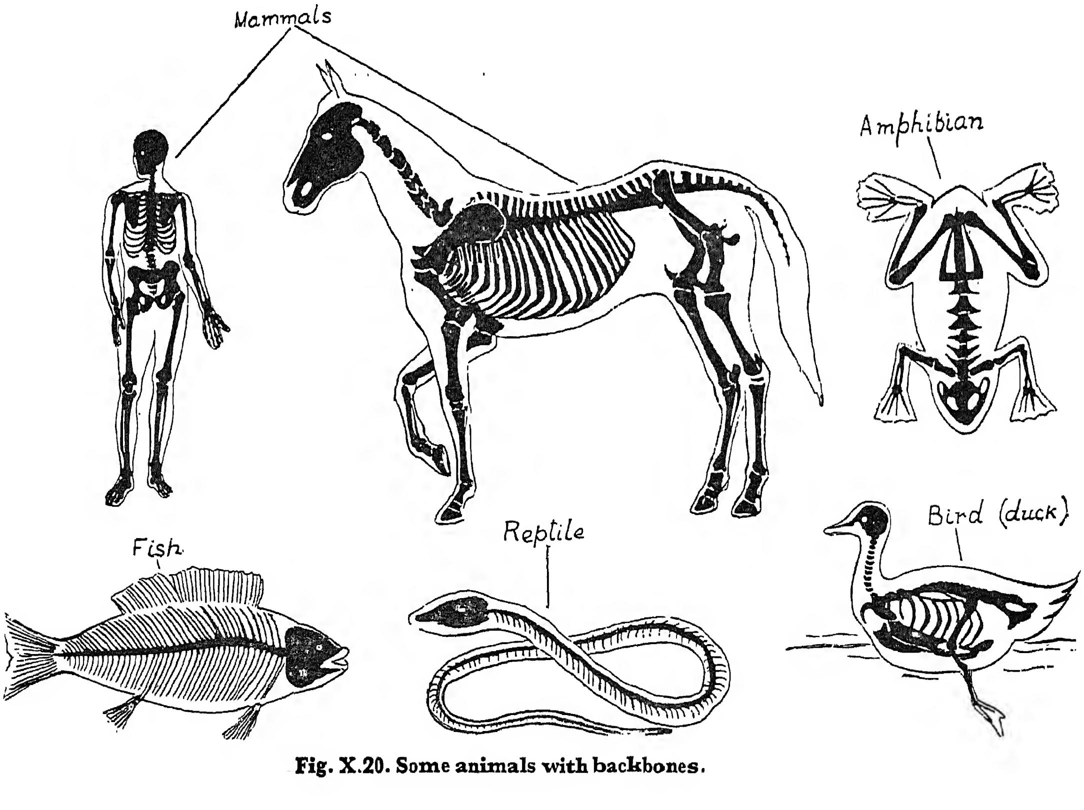


Fig. X.20. Some animals with backbones.

Major Concept 2. Vertebrates can be further classified into mammals, birds, reptiles, amphibians and fishes.

Concept 2-a (p. 110): Mammals are vertebrates which are warm-blooded, have hair and lungs, breathe air, and feed milk to their young ones.

To help you discover that there are a number of big groups of animals with backbones, make a list of those which give birth to young ones directly without any intermediate stage. How do they care for the young? Do they feed them? What is the nature of the skin? Is it smooth or covered with hair? Do they breathe air through lungs? Do they feel warm? Their body temperature is the same whatever the outside temperature. They are *warm-blooded* animals. Make a separate list of those animals which have backbones, are warm blooded, have lungs, breathe air and give milk to their young ones. This group is called *mammals*. In what group will you place whales and the *Platypus?*

Concept 2-b (p. 110): Birds are vertebrates which are warm blooded, have feathers and lungs, breathe air, have beaks and no teeth, two wings and two feet.

You have seen birds which fly in air. How do they fly? With what are their bodies covered? How do they breathe? Do they have a backbone? The bones of birds are very light; some are hollow. Examine a chicken or bird bone. Can you find the air spaces?

Visit a museum and study the skeletons of a few birds. Also see the stuffed birds and note their beaks and feet. Visit a zoo or a bird sanctuary and see the birds in the bird houses. Do birds have teeth? Compare them with other animals you know.

Concept 2-c (p. 110): Reptiles are vertebrates which are cold-blooded, are covered with scales, and which breathe air through lungs.

Observe house lizards, garden lizards, turtles, snakes, alligators and crocodiles, if possible. List their characteristics. Note the presence of a backbone, that they take on the temperature of the surroundings, that is, they are cold-blooded. Observe how they breathe and that their bodies are covered with scales.

Visit a zoo to see the reptile house. Observe the behaviour of these animals.

Concept 2-d (p. 110): Amphibians are vertebrates which are cold-blooded, have a skin without scales, and live a part of the time on land and a part in water.

Observe the characteristics of a frog with regard to the points mentioned above. Note the differences between the reptiles and the *amphibians*. Feel the skin of a frog. Has it got scales? Is it cold-blooded? Why is this animal called an amphibian? Has it a backbone?

Concept 2-e (p. 110): Fishes are vertebrates which are cold-blooded, have fins and scales and breathe through gills.

Look at fish and describe their characteristics. (Refer to Fig. X. 2). Do they have a backbone? Do they have scales on their skin? Are they cold-blooded? How do they swim? What organs help them in this? How do they breathe? Where does the oxygen come from? Draw a diagram of how a fish gets oxygen from the water. (See Fig. X.3)

Major Concept 3. Invertebrates can be classified into several groups.

Concept 3-a (p. 110): Insects have six legs, one or two pairs of wings, three body parts, and two feelers. They breathe by air tubes (trachea), and lay eggs.

Observe a butterfly and an ant. Look at a beetle and a mosquito. Do they look alike? All these are called *insects*. Find out some of their characteristics by answering these questions:

1. How many pairs of legs have they?

2. What are the two long structures on their head?

3. Their bodies seem to be divided into three distinct parts. What are they called?

4. Do all of these have wings?

5. Do their eyes have the same structure as our eyes? Read about compound eyes.

6. How do insects breathe? They do not have lungs like the frog, or gills like the fish. Look up about tracheae or air tubes and spiracles. Study the illustration of the breathing apparatus of an insect. (Fig. X. 22)

Try this as an investigation.

Capture a couple insects of this kind. Observe where you found them. What were they eating? Take some of these plants. Set up as natural an environment as you can, then study the behaviour of the insect in captivity.

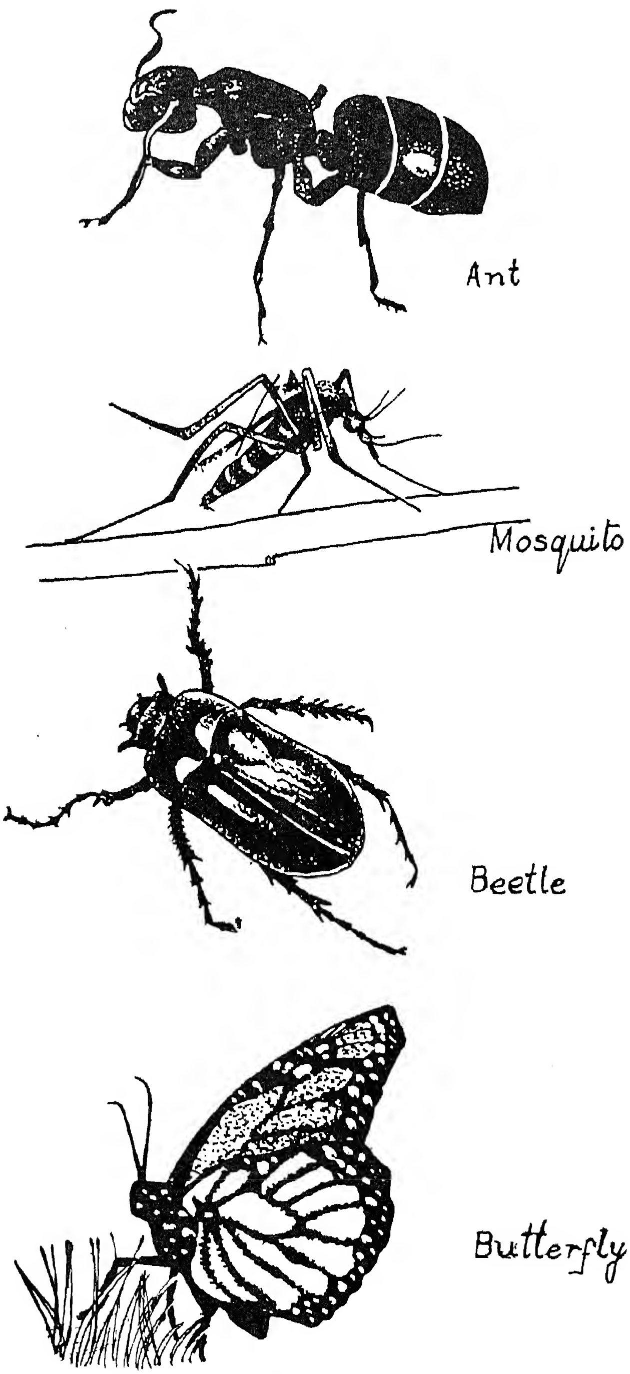


Fig X. 21 Some different kinds of insects

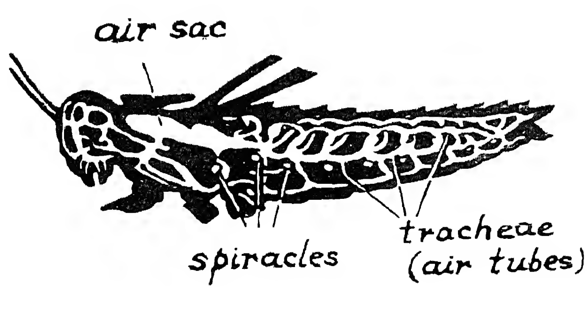


Fig. X.22. Diagram of the abdomen of the grass-hopper. Indicates the arrangement of the respiratory system.

Concept 3-b (p. 110): Snails live in water and have a strong shell for protection. Oysters are sea-animals living in shells. One type of oyster produces pearls.

Can you mention a few animals which have an outer shell with the soft bodies inside them? Early in the morning in the rainy season, if you visit a garden you will find snails. Watch a snail crawling slowly. Touch it and see how the animal quickly withdraws itself into the shell. Where does it normally live? Some are land snails and some live in water.

Visit a seashore and pick up different kinds of shells. You will find some joined by a hinge forming two-valved (bi-valved) shells. Find a picture of a pearl oyster and make a drawing. Does the oyster live in a two or bi-valved shell? Find out more about pearls and their formation.

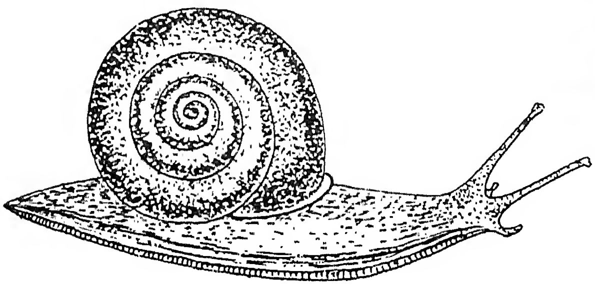


Fig. X.23. The land snail, an animal without a backbone.

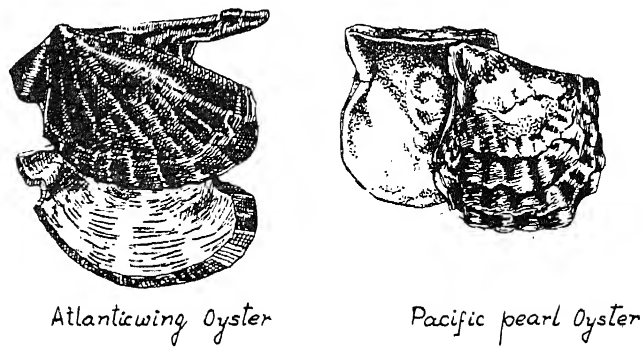


Fig. X.24. Oysters, with two or bi-valved shells.

Concept 3-c (p. 110): Spiders and crabs have eight legs for locomotion and two pincers for catching and cutting.

You have observed the house spider. How many legs does it have? Can you name any other animal with eight legs? Those living in water such as crabs have hard outer shells. Besides the legs, do you find any other common structures? For what are they used?

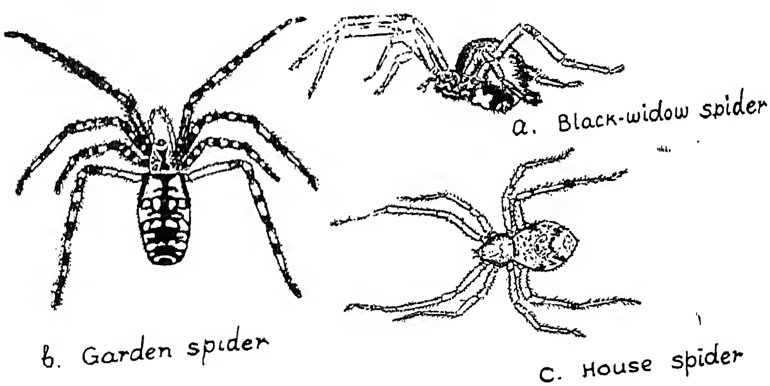


Fig. X.25. Spiders of various kinds.

Concept 3-d (p. 110): The earthworm is a segmented, muscular ringed worm.

You have in earlier classes studied the earthworm. Visit a garden on a rainy day or when the soil has been recently turned over. Handle the worms you may see there and examine them. How do they feel? Are they stiff or muscular? Do you notice ring-like marks in its body. (Refer to Fig. X.1).

Earthworms make an interesting study. Devise experiments to study how they respond to stimuli of light, sound, touch, and moisture. Try touching the bristles on the back with the tip of a pencil.

UNIT XI Scientists at Work

CLASS VI

Major Concept 1. By their work scientists like Priestley, Lavoisier, Pasteur and Harvey inspire us to achieve our goals.

Concept 1-a (p. 112): Scientists often hold convictions that are not popular at the time, e.g., Pasteur's germ theory of disease, Harvey's theory of blood, the Raman effect, Galileo's explanations of gravitational pull, Priestley and the phlogiston theory, Copernicus and the geocentric theory of the universe.

1. Read the biography of Pasteur, Priestley (1822-1895), Harvey, Copernicus and Galileo. Read of Raman's discoveries in India. Did people believe what these scientists were saying? Were their theories accepted immediately?

2. Read over the following excerpt from Pasteur's life to see how he was made to prove publicly what he knew to be true: 'Less than a hundred years ago Louis Pasteur, a French chemist, became interested in the prevention of diseases in animals. At that time in southern France a large number of sheep were dying each year of a disease called *anthrax*. Robert Koch, a German scientist, had already discovered the bacterium (a tiny one-celled plant) that caused this disease. Pasteur believed that weakened anthrax bacteria ('bacteria' is the plural form of 'bacterium') injected into the body of a sheep over a period of time would prevent the sheep from getting the disease. In order to test his belief, he decided to try it out with sheep. At first he injected the animals with a very small amount of weakened anthrax bacteria. As he continued the injections, he gradually increased the amount of bacteria. Finally he injected an amount sufficient to kill an untreated sheep, but, as Pasteur had expected, the sheep were not affected. He proved to himself that the injections had protected the sheep against anthrax.

'When farmers learnt of Pasteur's successful experiment, they begged Pasteur to save their sheep from anthrax, but the veterinarians, (men who treat the diseases or injuries of animals) ridiculed Pasteur's idea. What did a chemist who was not even a doctor know about animal diseases? A public demonstration was arranged to determine whether or not Pasteur's treatment was effective.

'The experiment was begun on May 5, 1881. Forty-eight sheep were divided into two pens. The sheep in pen 1 were injected with weakened anthrax bacteria at regular intervals, those in pen 2 were not treated. About a month later a deadly amount of the bacteria was given to the sheep in both pens. The results were awaited with anxiety and excitement. Would the sheep that had been treated survive? Two days later none of the sheep in pen 1 had developed anthrax; all except two in pen 2 had died, and those two died later. These results proved, as had Pasteur's earlier experiment, that sheep could be protected from anthrax.'

Pasteur began with a belief that sheep could be protected from anthrax by a series of injections with bacteria. Such a belief is called a *hypothesis*. After Pasteur had formed his hypothesis, he conducted experiments and made observations to test it. The results of his experiments proved

that the hypothesis was correct. Pasteur had used the *experimental method.*

3. In 1628 William Harvey published his book, *Motion of the Heart and Blood in Animals.* Review this history. What was happening at this time in your country? in English history? in other parts of the world? Construct a time line on which you place some of the major events in history along with scientific discoveries, such as Harvey's, that changed men's thinking. Medical thinking for some two thousand years before Harvey was dominated by the theory of the four humors (blood, phlegm, black bile, yellow bile). Health was thought to consist of the humors in correct proportion and diseases arose from an excess of one humor or another.

Each humor was associated with an organ of the body, such as blood with the liver and phlegm with the lungs. Find out more about this theory. William Harvey clearly presented the idea that each organ has a function related to all other organs in the body and to the body as a whole. Through his many experiments, the circulation of the blood was demonstrated and proved. Learn more about Harvey's life and experiments.

4. Is it difficult for you to believe that men like Gioradano Bruns were burnt at the stake for the heresy of their scientific ideas?

It has been said that scientists like Copernicus (1473-1543), Galileo (1564-1643), Kepler (1571-1630) and Newton (1642-1727) did not have the simple task of merely criticizing faulty theories of science; they had to destroy the old theories and rebuild others.

Get some one to build up a case to defend this statement: 'The earth is the centre of the universe'. Get some one else to build the case for: 'The sun is the centre of our planetary system'. State the effects resulting from holding either of the theories. Which one is inadequate?

It was believed by scientists for some time that there was an element called 'phlogiston' which caused burning. There had long been a search for whatever it was that kept fires burning and animals living. They spoke of 'an air in which a candle will burn'. The whole experimental approach to learning about what the constituents of air are, reads like a story. Try to find out about Priestley and his discovery of oxygen. Study the illustration of his famous experiment. Just as Priestley believed in science experiments to find answers to his questions, so did he believe in freedom and liberty of the individual. He and his family suffered because of his liberal views.

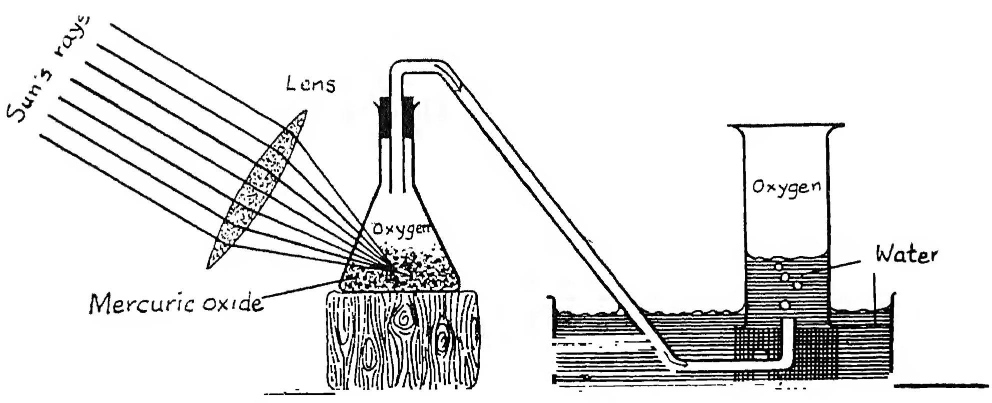


Fig. XI 1. Accidental discovery of oxygen by Priestley.

Concept 1-b (p. 113): The accomplishments of scientists often appear like a chain reaction in thinking, i.e., one thing seems to lead to the next.

Check on the work of chemists like Joseph Black (1728-1799), Joseph Priestley (1733-1804), and Anton Lavoisier (1743-1794) to see how the scientific experiments of each contributed to the other. You will be interested in Black's study of carbon dioxide, that Priestley discovered oxygen,

but did not find out its place in combustion, Scheele's discovery that oxygen is an element, and that Cavendish found that water is a compound of oxygen and hydrogen and not an element, but Lavoisier finally established the role oxygen plays in combustion.

Describe an important discovery each of these men made and weave this into a dramatic skit.

Think of other examples of how one man's achievements aided another, as for example Pasteur and Lister.

Concept 1-c (p. 113): Madame Curie made an invaluable contribution by her discovery of radium and her work on radioactivity.

Perhaps you can name scores of cinema *actresses*, dance experts, and women famous in social service and other acitivities, but how much do you know of women scientists? Read about Madame Curie and also of her daughter Irene, who became a Nobel Prize winner. Read how Madame Curie, one of the first discoverers of radioactivity, was the first woman professor in the 650-year old University of Paris, and how she laboured under difficult conditions to carry on the research to isolate radium.

Find out about the Nobel Prize. The Nobel Prizes are a group of five awards given each year. Three are given for important work in areas of science, one for literature, and one in achievements toward world peace. The three areas of science are chemistry, physics, and physiology or medicine.

Alfred Nobel was a Swede. The awards are open to anyone in the world. They are not given for general achievement over a period of years. Instead, Alfred Nobel stated in his will that the prizes shall be awarded 'to those who, during the preceding year, had conferred the greatest benefit on mankind'. The winners receive a portion of the income from Nobel's great fortune. The money usually allows the winners to carry on the work they have been doing. They also receive a gold medal. These are probably the most important international awards for human achievement. Are all prizes for science? To whom are they given? Does India have any living Nobel Prize winner? If so, what did he do? Are there any women scientists in India today? In what fields do they do their research? List the qualities you believe a woman in science should possess.

Major Concept 2. Scientists in all ages have been interested in improving conditions of man's life; for example, Pasteur with his germ theory of disease and Fleming with his discovery of antibiotics.

Concept 2-a (p. 113): Pasteur improved man's living conditions by his discovery of the germ theory of disease.

1. Do you believe that germs cause disease? Germs are any bacteria, fungi, viruses, or one-celled animals that cause disease.

(a) Some people thought disease was sent by the gods to punish man.

(b) Others thought disease was caused by 'bad' air or 'bad' blood.

(c) Demons ~~who~~ captured men's bodies were thought to cause disease.

2. Why was it that so many years passed before people accepted the idea that germs cause disease? Read about the discovery of the microscope and its use in observing germs.

3. Give a report to your class on pasteurization.

Concept 2-b (p. 113): Fleming helped human welfare by his discovery of penicillin and antibiotics.

Have you ever taken moulds or fungi in any form. Some antibiotics are made from moulds and fungi.

Have you ever taken an antibiotic? Which one? Ask a chemist to explain to you how valuable antibiotics are as an aid to human welfare. List some of the diseases prevalent in your area which they help to control.

Major Concept 1. The achievements of a scientist like Copernicus, Dalton or Kepler are often in many fundamental fields.

Concept 1-a (p. 113): A scientist works primarily to find out the nature of things.

1. Make a time line of the great scientists, showing the times in which they worked and a notable achievement of each. How can you plan your time line so that others may learn from it? As you study this, does it give you a link with other historical facts?

2. Study about Dalton (1766-1844). Though known for his atomic theory, was this all he did? Discover the fascinating study of his life as the son of a poor English weaver, how he always solved mathematical problems, opened his first school in a barn and had a consuming hobby of making weather observations. For 46 years he did this, collecting some 200,000 observations. He reasoned thus: How were the gases of the air held together? Were they chemically united or just a mixture, as clay and water? Perhaps the gases were composed of small particles of matter. Kanad, of India, conceived of matter as made up of atoms, centuries before Dalton. Leucippus of ancient Greece had also speculated on the nature of matter. Dalton kept on asking questions like this; Are all atoms alike in both shape and weight? Do you find from your readings that Dalton, like many other scientists, worked in several areas of science?

3. Find out about the German astronomer, Kepler (1571-1630).

Concept 1-b (p. 113): Scientific truths have replaced superstitions and dogmas.

1. Every nation has superstitions. Some are international. Do you have any superstitions? List the superstitions your class believe. Can you see how they originated? What scientific facts might help in removing such superstitions? Analyse one of your own beliefs. How did it start? Should you continue to believe it?

Do you believe the common saying about the crow cawing on the roof? Will a guest always come?

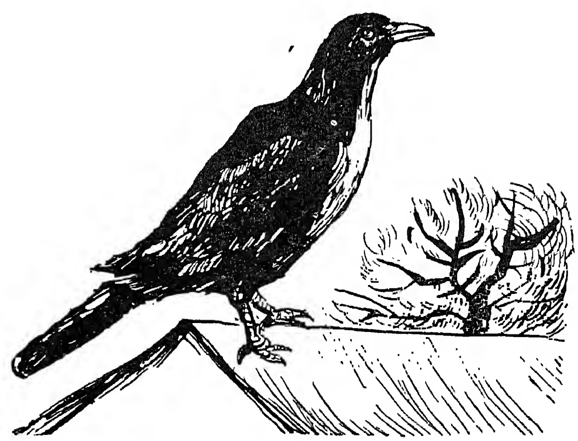


Fig. XI.2. Does a guest come when the crow crows?

Do you know anyone who wears an iron or steel ring to protect him against bad dreams at night or other dangers?

What about black cats crossing your path?

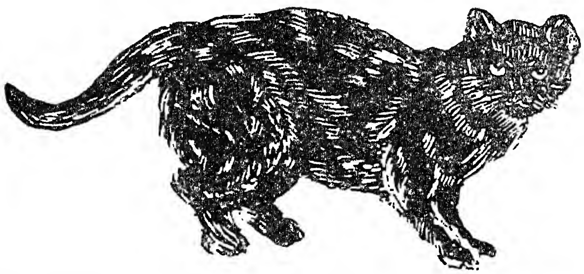


Fig. XI.3. Do you believe a black cat brings bad luck?

Do you believe that if you put a horse's hair in a water trough, a snake will take its place?

2. How do superstitions begin? Are they based on fear and lack of knowledge? Primitive man viewed the stars, the moon and the sun with fear. He had little knowledge of nature. Superstitions became the explanations of phenomena of the heavens.

For example, a comet came to be thought of as a sign of disaster to come. Perhaps disasters *have* come at the same time as comets appeared, but this does not mean that the comet *caused* the disasters. Now we know comets travel on paths about the sun and make their appearances regularly.

Can you think of a proverb that was caused from not observing accurately? Have you ever observed an ostrich with its head buried in the sand? Many people believe this is what ostriches do.

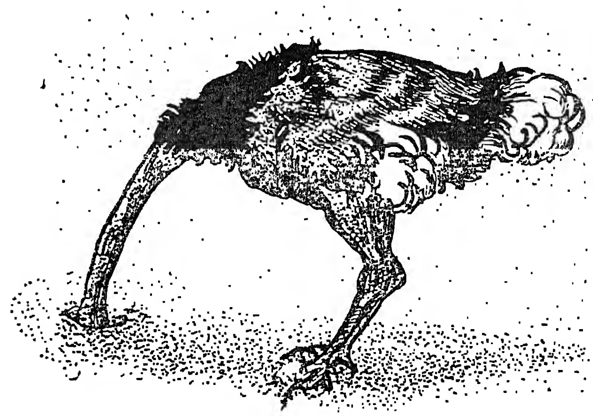


Fig. XI.4. Does this really happen?

Major Concept 2. Often a pressing problem drives scientists in several parts of the world to seek a solution.

Concept 2-a (**p. 113**): The problem of producing electricity was studied by many scientists at the same time—Oersted, Faraday, George Ohm, Joseph Henry, Andre Ampere.

1. It has been said that when Thomas Edison (American scientist, 1847—1932) invented the electric light bulb, someone in Italy had also done this. Similarly, when Darwin was about to bring out his *Origin of Species*, Wallace had also come to the same conclusions about evolution. Scientists work in different parts of the world on similar problems. Find other examples of this. Make a chart of the story behind electricity to show this, giving the names of men, dates, and their contributions to knowledge in this field.

2. Read the life story of the American scientist, Benjamin Franklin (1706—1790). You will find that while Benjamin Franklin was making plans to build a very high steeple, one high enough to reach the clouds, so that he could study lightning, two French scientists succeeded in getting sparks from the lower ends of tall pointed rods during a thunderstorm. (Is lightning a form of electricity?)

Study the following list: English scientist Michael Faraday (1791—1867), Danish scientist Hans Oersted (1777—1851), German physicist George Ohm (1797—1854), American scientist Joseph Henry (1797—1878), French physicist Andre Ampere (1775—1863).

Pick out some significant events from these scientists' lives to build some class interest. See if your class can guess who these men are, for example:

'He was a poor boy in England with little education, who discovered the joy of reading while he was working in a book binder's shop. He enjoyed reading about electricity and magnetism. He knew that if a current was sent through a coil of wire, there was a magnetic field produced. As he grew and studied, he wondered if perhaps a magnet could make an electric current. He was right. He became known for his remarkable theory. It is the principle behind the electric generator. Who is this scientist? See the illustrations from his diary.'

3. Develop stories of others who led the way in several countries.

4. Try Oersted's experiment which shows that a conductor carrying an electrical current is surrounded by a magnetic field. Connect about 2 metres of insulated wire through a switch to three dry cells connected in series. Place a compass near the wire and hold the wire parallel to and above the compass needle. Close the switch and observe the movement of the needle.

Hans Oersted, in 1819, while lecturing to a science class, inadvertently placed a wire carrying an electric current near a compass needle. To his surprise the needle turned to a new position nearly perpendicular to the wire. Is this what you found? Reverse the direction of the current. Observe the needle now.

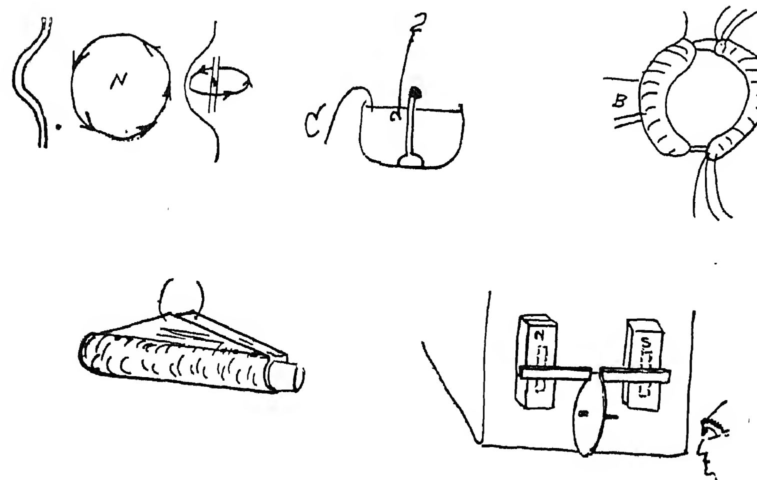


Fig. XI.5. Sketches from Faraday's notebook, indicating the progress of his electromagnetic experiments.

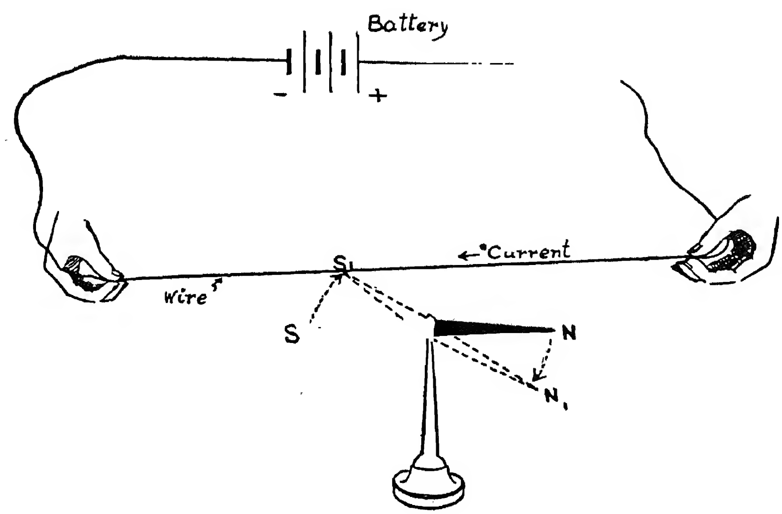


Fig. XI.6. Is there a magnetic field about a current-carrying wire?

5. Find some films on the lives of great scientists.

6. You will be interested to note that Joseph Henry in America found a way of producing an electric current by moving a magnet through a coil of wire. What was happening in England at the same time?

There are other names found in the long history of electricity, Thales of Greece, William Gibert, Von Guericke Galvani, Volta. Find out about their lives. What difficulties did they encounter?

Concept 2-b (p. 113): Experiments of several scientists such as Eijkman, Hopkins, Funk and McCollum resulted in the discovery of vitamins.

Which is more wholesome, whole grain flour or refined grain flour? Do you know any one who has *rickets*? *Pellagra*? *Scurvy*?

1. On your time line of scientists and their achievements where will you place the discoveries of *vitamins*? You will recall that when Magellan sailed around the world more than 400 years ago, his sailors' mouths became sore and their gums bled. Their joints swelled until the men screamed in pain. They had the disease known as scurvy. How long was it before scientists found that vitamin C could protect people from this deficiency disease? The work in 1747 of Lind, a British surgeon, will interest you.

2. Scientists all over the world worked on the problem of nutrition. Check the life stories of men like: Hopkins in England, who coined the word 'vitamins'; Funk, a Polish chemist; McCollum in America; Eijkman working in the Dutch East Indies.

Read about deficiency diseases and thereby become acquainted with the men who contributed to the discovery of vitamins.

You will be interested to know that during World War I, the British troops in the Dardanelles and Mesopotamia who were on a diet of white bread, suffered severely, but the Indian troops, whose diet consisted of whole grain flour and chick peas, did not have the deficiency nerve disease known as 'beri beri' due to a lack of vitamin B. Explain this.

3. Who are the scientists in India working in the field of nutrition? Find out about Nutrition Institutes such as the ones in Mysore and Hyderabad.

Concept 2-c (p. 113): Wireless waves were discovered by both Marconi and J.C. Bose.

1. What does the name Marconi bring to your mind? Marconi (1874—1937), was an Italian physicist who invented wireless telegraphy. When he was sixteen, he demonstrated that an electric current will travel in a direct course without a conductor if started in a particular direction.

Four years later when he was twenty, he demonstrated the transmission of signals using electric waves. The Italian Government did not recognize his work, so he went to England where he was granted the famous No. 7777 patent, the first wireless patent. Continue with this story. Has the end really been written in radio research?

2. Find out about the work of the Indian scientist J.C. Bose.

3. Where will these men be on your time line as you add scientific endeavours?

Concept 2-d (p. 113): Theories of evolution were developed by Darwin, Wallace and Lamarck.

1. Soon you may be studying biology. A French naturalist by the name of Jean Baptiste Pierre Lamarck (1744—1829), invented the term 'biology'. He is best known for his theory of evolution. He worked 50 years before Charles Darwin. He made a distinction between animals

with backbones and animals without. He developed a 'ladder' of evolution with the vertebrates at the top.

He thought that the habits and ways of living animals caused inherited changes in the body form. Where an organ is used, it develops and stays, and when it it not used, it diminishes and becomes atrophied. What do you think he said about the long neck of the giraffe and its eating habits? Is this theory still believed?

2. Does the name of Charles Darwin (1802—1882), make you think of finches and the Galapagos Islands?

Did you know that people used to believe that every kind of plant and animal had been created during the first days of the world and that all things have remained exactly as they originated?

Darwin did years of careful study starting from the famous five-year voyage of the *HMS Beagle*, where he made valuable collections of specimens from all parts of the world. He pondered about the different species of animals on the Galapagos Islands which were never a part of the mainland. How then did different species of animals get started?

Darwin reasoned that those species best suited to their environment would survive and reproduce themselves.

Before publishing his ideas a letter reached him from a fellow naturalist, Alfred Wallace, working in Malaya. Wallace had come to the same theory. Later they shared honours for this, but the world was not ready for the theory and Darwin had to withstand violent criticism. Give a report on Darwin and his researches.

Major Concept 3. Scientists pool and share their knowledge through national and international agencies.

Concept 3-a (p. 113): The International Geo-physical Year was celebrated in 1959 with the cooperation of all major nations of the world, to investigate the air, sea, weather, the geo-physical aspects of the earth's interior, etc., by international collaboration.

1. What do the letters IGY mean? Perhaps some of your older brothers or sisters followed the events of the International Geo-physical Year. Look up the word *geo* in the dictionary. What other words begin with this prefix? (*geo* refers to the earth).

The IGY is an example of international co-operation. Twelve nations set up 35 camps from which they probed deeper into the earth's story. What their problems were in setting up camps in extremes of temperatures where neither men nor instruments could function normally, is indeed a dramatic story. By helping each other, the nations solved many problems. Here are some of the things studied. (You may like to find out more about each one, as the result of their researches have been put on films and in books. The aurora, weather, rays from the upper atmosphere, depth and structure of ice, etc. They found much more ice than they expected, but less land under it. They found that East Antarctica is a continent; whereas West Antarctica is a series of islands bridged over by ice. The ice averages 8000 feet in thickness. Can you imagine 8000 feet of ice? Can you imagine a South Pole temperature of -125°F/-87°C? Find out more about their discoveries.

2. Try to borrow films such as *The Planet Earth Series* or *Camp Century—A City Under Ice*, for your class.

3. Here are some topics you can report on:

(1) Sun spots, origin of the invisible rays of the sun (X-rays, ultraviolet rays, infra-red rays), cosmic rays, electro-jets.

(2) Van Allen belts (electrons and protons given off by the sun.)

(3) Artificial satellites for gathering information about weather, ionosphere, etc.

(4) Study of glaciers and their effect on climate.

(5) Oceans, sea-level changes and weather, ocean currents.

(6) Shape and size of the earth. Gravity measurements.

(7) Earth's weather and how it is changing.

The IGY findings have awakened the governments of the world to the need for continued research in many fundamental fields.

Concept 3-b **(p. 114)****:** UNESCO is an agency for international exchange of information about science and its many applications.

1. Did you know that millions of grown-up people in the world cannot write their own names?

What do the letters in UNESCO stand for? United Nations Education, Scientific and Cultural Organization is one of the specialized agencies of the UN (United Nations). Study the aims of the organization. Discuss them. UNESCO has set itself ten main tasks:

1. to make sure that every child in the world is taught to read and write;

2. to help everyone in the world to get an education which will fit him or her for a useful job, and which develops each person's special talents;

3. to encourage educators everywhere to spread respect for human rights;

4. to get rid of barriers to the free exchange between countries of people, knowledge and ideas;

5. to encourage progress in science and the practical use of scientific discoveries for man's welfare;

6. to study the sort of human feelings that lead to war and to correct them through education;

7. to prove to people that they will benefit from understanding the culture and customs of other countries and that no country's way of life is completely independent of other countries;

8. to promote truth, freedom, and peace through newspapers, radio, and motion pictures;

9. to convince people from different countries that they should work together and get to know one another's problems through the UN; and

10. to provide a service for exchanging knowledge, plans, and money that will aid in carrying out the above purposes.

Education is UNESCO's main field of activity, but helping developing countries to improve agriculture, industry, and science is also an essential part of their programme.

2. Some of you will know people who work for or with UNESCO and you can interview them. Also there may be a UNESCO office in your city where you can get pamphlets. Others may wish to write to the nearest UNESCO office for information.

Major Concept 1. The contribution of scientists like Shapley and Eddington greatly expanded man's knowledge of the universe.

Concept 1-a (p. 114): Many discoveries led to knowledge about the vastness of the universe.

If you have not made a time line of scientists and their discoveries, make one so that you can link up other knowledge which you gather about science achievements that changed men's lives. Where would you put Copernicus on your time line (1473-1543)? Here was a great Polish mathematician and astronomer who believed that the sun was the centre of the universe, whereas most of the world refused to consider anything but the earth as the centre. Copernicus' theory was very radical and he did not dare to publish it. Some of his ideas have been disproved, but his clear, free thinking, plus observation, led the way for a new scientific era.

1. Reconstruct a model of the universe before Copernicus, with the flat earth as the centre and a dome of stars.

2. Picture what Copernicus' theory did to your model, with the sun as the centre.

3. Now draw a picture of what you think the universe is. Does it show that neither the sun, nor the earth, nor even our Milky Way galaxy is the centre of the universe? Far from being the centre of all space, our sun is only a minor star not even in the centre of our Milky Way galaxy. How have man's researches altered the pictures of the universe? Do you believe the universe is expanding?

4. Find out about astronomy. Who were the great scientists who helped change the idea of the universe? Find out about: Galileo, Kepler, Newton, Brahe, Huygens, Bode, Hale, Herschel, Laplace, Shapley, Jombaugh, Lowell.

Concept 1-b (p. 114): Better tools and improved methods of investigation like spectrograph, photography, telescopes, and radio telescopes have given man a wider and deeper knowledge of the universe.

Until 300 years ago, man's universe consisted of what he could see with his eyes: a sun, our earth's moon, five planets, and a few thousand stars. As you know, he considered the earth as the centre of the universe; all else revolved about the earth.

1. Try to construct a crude instrument (refracting telescope) such as Galileo (1564-1642) used for viewing the heavens. The date was 1609. He used a simple cylinder with an eye piece lens and another lens at the end of the cylinder to collect light. He was the first man to look at the stars with a telescope: he saw the rings of Saturn, but he could not distinguish them with his crude telescope, he noted that the planet Venus had phases like our moon; he saw four of Jupiter's moons. His careful observations over the years and the accuracy of his drawings along with his predictions made him one of the greatest scientists who ever lived. Bigger and better telescopes had to be made to improve on his observations.

2. Find out how a telescope works. Draw a refracting telescope. With two reading glasses (convex lens) and a couple of cardboard cylinders, one smaller than the other to allow movement of the smaller inside the larger, a crude refracting telescope can be made (see fig. XI. 7).

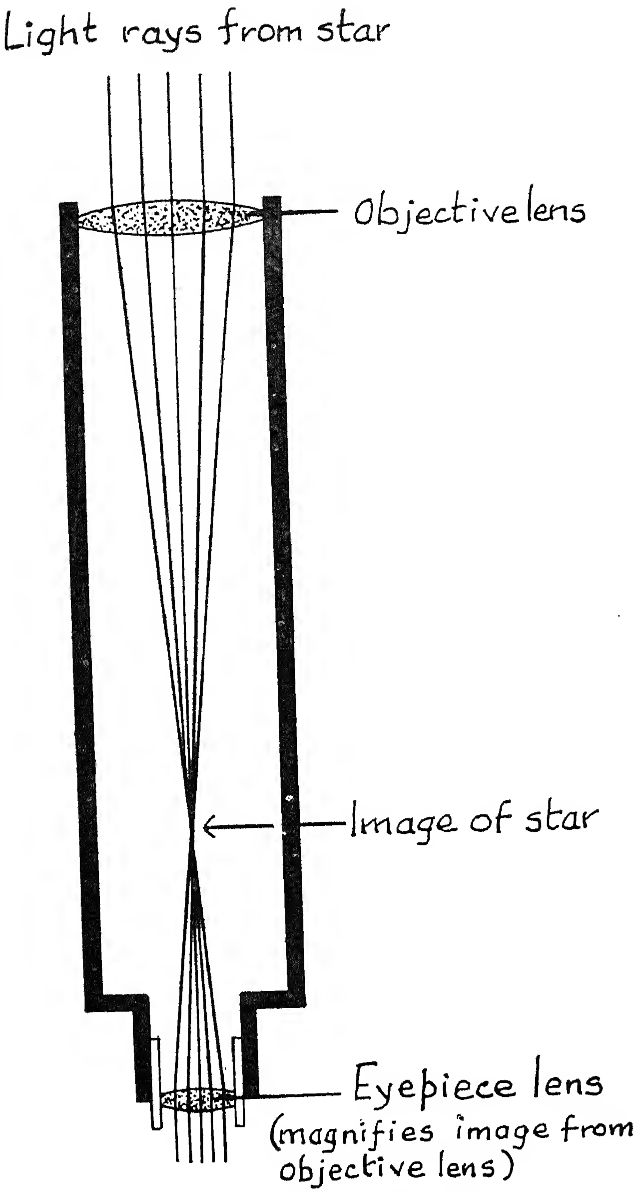


Fig. XI. 7. A refracting telescope.

3. Find out about modern telescopes such as the one on Mount Palomar in California. It has a 200 inch mirror. It took 15 years to build. Photographs are taken of distant stars so far away that it has taken their light a billion years to reach earth—and light travels 186,000 miles each second. These giant telescopes using mirrors are called 'reflecting telescopes.'

4. What are the other instruments used today to increase man's knowledge of the heavens?

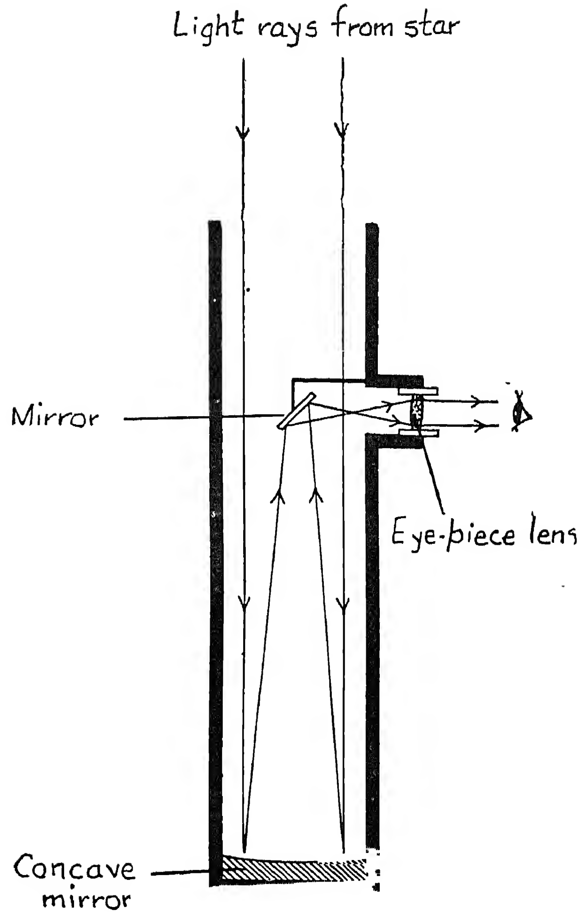


Fig. XI. 8. A reflecting telescope.

What is a spectroscope? Make a special report about a spectroscope. How does the spectroscope work? The telescope can bring us the light from the stars, but the spectroscope can analyse the light and tell us astonishing things about the star from which the light came. The new study of astrophysics has been made possible because of the invention of the spectroscope. As the light passes through a thin slit in the spectroscope, it is broken up by a prism into a spectrum of many coloured lines. (Refer to Fig. VI. 76.)

Scientists know that a particular element such as iron or copper will produce a certain set of spectral lines. Each set of lines might be said to be a finger print of a particular element, different from that of all other elements.

The spectrograph is attached to the telescope and the telescope is aimed at a particular planet

or star. The lines in the resulting spectrogram, either seen through the eyepiece lens or photographed on special film, tell the astronomer what element in the star or planet caused them.

5. Here are some other instruments you will wish to learn about. Plan a report, including a diagram, on tower telescopes, radio telescopes, Palomar reflecting telescope, interferometers, and cameras used by astronomers.

6. Try this experiment to acquaint yourself with radio telescopes. Use your portable radio and a fluorescent light. Set your radio to a 'silent place' between two stations. Bring it to within one inch of the light. Do you hear a buzzing sound? The light is 'broadcasting' radio waves. Move the radio along one side of the light. Move it across under the light. Are the sounds different?

Radio telescopes with huge parabolic antennas or radio 'ears' can detect changes taking place on stars and planets. Radio-astronomy is a new field of study.

7. Have two classmates hold a newspaper over the light while you locate the unseen light with your radio. Your radio has a tiny antenna inside. With large antenna you could do your locating from a greater distance. Look at pictures of radio telescopes. See why the antennas are hundreds of feet in diameter?

8. Write to some of the great observatories in the world for information.

(i) Observatory, Kodaikanal, Madras State.

(ii) Observatory, Simla, Punjab.

(iii) Yerkes Observatory, Williams Bay, Wisconsin, USA.

(iv) Lick Observatory, Hamilton, California, USA.

(v) Mt. Wilson and Palomar Observatory, California Institute of Technology, Pasadena, California, USA.

(vi) Greenwich Observatory, Greenwich, England.

9. Prepare a bulletin board illustrating the tools of the modern astronomer.

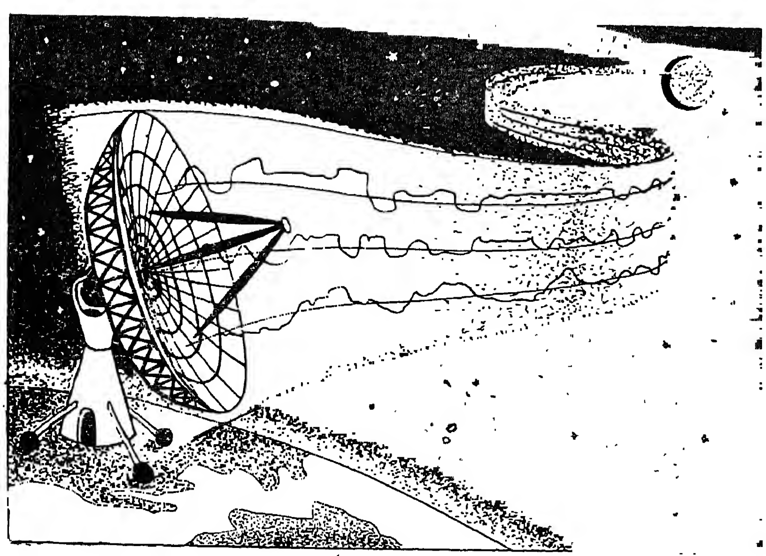


Fig. XI. 9. A radio telescope.

Major Concept 2. Some scientists make spectacular discoveries that entirely alter the ways of thought and life.

Concept 2-a (p. 114) : Scientists like Faraday and Marconi made fundamental discoveries which made possible the present day use of electricity and radio in everyday life.

1. You have found out some things about Michael Faraday (1791—1867). Perhaps you have heard it said, 'He electrified civilization' by his discovery that electric current can be induced from a magnetic field. Write a short essay developing this idea. Cite its uses in today's life.

2. Take another scientist working in a different field, perhaps Marconi in wireless telegraphy. Write an essay showing how he too affected civilization by his discoveries. Why does this scientist seem very much alive, and in our midst today?

Concept 2-b (p. 114) : The discoveries of Einstein, Rutherford, Bohr and Fermi have given a completely new concept of matter, energy and structure of the atom.

The lives of great scientists go on changing the world as surely as they transformed their world when they made their discoveries.

The giants of science stand on the shoulders of other scientists. Simultaneous discovery by two or more men often happens in science. Many men contributed to our completely new concept of matter, energy, and the structure of the atom. The name of Einstein stands out, but read to find out for yourself how others contributed to these ideas.

Have you ever stopped to wonder : What is space ? What is time?

1. Before the theory of relativity came to be known, time and space were thought of as two different things, but in 1908 Minkowski said that they were integrally related as 'time-space', not separate space with three dimensions, and time as something separate.

Before relativity, men thought of space as filled with 'ether' that was at rest, so the motion of any object in the universe could be measured by comparing its motion to the ether. The theory of the ether has been discarded, There is, according to scientists today, no absolute space and time, only relative space-time. Some day you will understand this theory. Try to find out through reading and perhaps interviewing mathematicians and physicists whom you know, who the men were who helped build this new theory. Here are some of them : Ernst Mach of Austria (1838-1916) and Edward Morley (1838-1923) American physicist, George Fitzgerald of Ireland (1851-1901), and Jules Henri Poincare (1854-1912) of France, Hermann Minkowski (1864-1909), Sir Arthur Eddington (1882-1944) of England, Albert Einstein (1879-1955) and Georges Lemaitre (1894-) of Belgium.

You may be interested to know that the first spark of Einstein's genius was observed when he was twelve years old when he was given a geometry book. When he was twenty-six he published his first paper on relativity. Read about his life.

2. What have you learnt about atomic energy? Find out about men like Bohr and Fermi;

Major Concept 3. All scientific discoveries have not yet been made.

Concept 3-a (p. 114): Each new theoretical concept, discovery or invention opens new opportunities for further investigations, for example, DNA.

1. Perhaps you think that because you have been reading about and discussing the lives of giants in the scientific world, that all discoveries and inventions have been made, and there is nothing more to be discovered. Are you right in thinking so? Have you tried to build a simple reflecting telescope? An amateur with a six inch (remember the Palomar mirror is 200 inches) reflecting telescope can discover things too. Amateurs observing and keeping careful records have found new comets. Others watch and tabulate meteors coming into the earth's atmosphere. Still others spend hours patiently measuring the brightness of variable stars. The drawings of those who look through telescopes at planets like Mars are valuable, because photography in the great observatories has some disadvantages. What talents do you have?

2. Some one has said these are the inventions that changed the world: the steamboat, the sewing machine, the telegraph, the telephone, the typewriter, the automatic type-setter, the electric power system, the aeroplane, the vacuum tube, and the transistor.

Do you agree? Why, or why do you not?

3. Make a list of problems that scientists are at work today. Does your list include:

(a) Cure of various maladies, like cancer.
(b) Physiological effects of extended space travel.
(c) Slowing up the process of ageing.
(d) Effects of cosmic radiation.
(e) New fuels and metals to withstand space travel.
(f) More information on what the cell is really like.
(g) More information on DNA. (Deoxyribose nucleic acid)
(h) New uses of nuclear energy for peace.
(i) Economical methods of making fresh water from sea water.
(j) What the inside of the earth is like.
(k) Television around the world by satellites.
(l) Better crops and better animals from improved methods of breeding.
(m) Is atomic energy the best substitute for oil, coal and natural gas, which resources the world is fast using up?
(n) Can the sun's energy be harnessed in any ways? (Solar batteries).

What have you listed as useful research? Can you see why new scientists are continuously needed today?

Concept 3-b (p. 114): Empirical studies and practical problems in the application of science have led to new discoveries.

1. Sometimes man, in attempting to apply or use some device already made, comes upon new and better ways to do the same thing. For example, the first sewing machine made a chain stitch which unravelled when broken. It took a lock-stitch machine to improve it, but this was never put on the market. Howe used a needle with its eye in front and an underthread shuttle and this has been used ever since. Scores of inventors have refined the sewing machine to make it a better tool.

2. Trace the improvement of the plough in this way.

3. Trace the improvement of the electric light bulb.

4. Think of Thomas Edison's phonograph compared to the Hi-Fi record players today.

What inventions led to their improvement? (microphone, vacuum tube amplifier, reproduction of sound on magnetized tape, etc.).

Fig. XI.10. Edison's first phonograph.

2. So you want to be a scientist? List all the qualities you have been finding in the lives of the men studied. Here is a list which you might check. Are these the qualities you think you should have?

Am I willing to work hard?

Am I patient?

Am I willing to be very careful and exact?

Am I open-minded; that is, can I change my mind in the face of new evidence?

Can I think straight?

Am I curious?

3. Watch the papers and magazines for news about science. Keep a scrap book of new ideas. Are there ideas you would like to explore?

UNIT XIII Our Universe

CLASS VI

Major Concept 1. The solar system includes the sun and all the bodies that revolve around it.

Concept 1-a (p. 121): There are nine known planets.

1. What is the first thing you do when you go out-of-doors at night? Most poeple look up at the sky. Science really started when men began looking at the sky.

Some of the brightest lights in the night sky are not stars at all, but *planets.* The brightest planet, Venus, you sometimes see in the east before sunrise; sometimes you see it in the west after the sun sets. It is never far from the sun. Do you know why?

2. Of course you have noticed that the sun always rises in the east, then during the day moves across the sky, and in the evening sets in the west. You may recall that the ancients thought the sun took a daily journey round the earth. How do we today account for this apparent motion of the sun, for its appearing to move from east to west across the sky each day ? We account for it in the same way that we account for the apparent motion of the stars across the sky from east to west each night. You surely know what makes the sun and stars and also the moon and the other planets *appear* to go round the earth each day.

If you will look at Table XIII.1, you will see that Venus is much closer to the sun than the earth, that it is only 67 million miles from the sun while the earth is 93 million miles from the sun. Does this fact tell you why we always look in the direction of the sun to see Venus; why we always find Venus in the western sky after sunset or in the eastern sky before sunrise? If you assume that the earth is rotating from west to east, and that Venus is going around the sun from west to east, and that Venus is closer to the sun than the earth you can understand why Venus appears where we find it. Try explaining to a friend why we find Venus where we do find it.

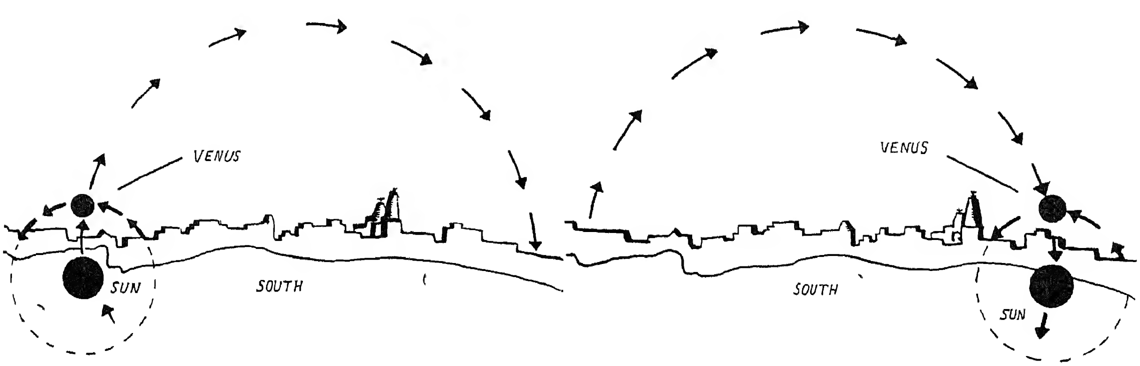


Fig. XIII.1. Venus as a morning star in the east and as an evening star in the west.

3. Can you find other planets in the night sky? Get an almanac to help you. The almanac will tell you when to look for certain planets and near what group of stars to look. Some newspapers carry a map of the night sky. Some science magazines may also give this information. Three other planets you will surely be able to see during the year are Jupiter, Mars and Saturn. Consult your almanac each year as the times for observing change. One year at a certain season, you may get this advice: 'Go out about dusk. Look in the western sky. Pick out the brightest object. It will appear as a very bright star. This is Venus.' Observe this planet for a month. Make several observations each week at the same hour of the evening. As the days go by does it appear higher in the sky, or at the same height, or lower in the sky? Can you find groups of stars which appear near to Venus? Does Venus appear to shift its position with reference to these other stars? It does, but you will have to make accurate records of your observations to discover this movement.

If you can find Jupiter or Mars in the evening sky, you may be able to detect their movement among the stars easier than you can that of Venus. In any case you must keep accurate records to observe this. It is the motion of these planets and of the earth round the sun that makes these planets appear to shift their position among the stars. Draw a diagram to show why this is so, or try explaining to a friend why this is so.

You should make observations on a few evenings on the direction of one of these planets at different times such as at 7, 8, 9, and 10 o'clock. In this case you will see that the planet you are observing has appeared to move westward. Account for this westward movement. Is it due to a motion of the planet or to a motion of the earth? What reasons have you for your answer?

4. If possible, observe the position of a planet among the stars for a period of three months. Plot each position on a chart with dates. Write a report on your observations.

5. Make a blackboard planetarium. Here are the facts needed for making this.

TABLE XIII.1. FACTS FOR A 'BLACKBOARD PLANETARIUM'

Number and name of planet	Distance from sun in millions of miles	Distance to be measured from left side of blackboard (Sclae: 1 inch = 20 million miles)
1. Mercury	36	$1\frac{3}{4}$ inches
2. Venus	67	$3\frac{3}{4}$ inches
3. Earth	93	$4\frac{3}{4}$ inches
4. Mars	141	7 inches
5. Jupiter	483	2 feet
6. Saturn	886	3 feet 7 inches
7. Uranus	1783	7 feet 5 inches
8. Neptune	2791	11 feet 6 inches
9. Pluto	3671	15 feet 3 inches

6. To give a more realistic picture of the planets, try putting the planets in orbit. Take a tall slender bottle like a large straight-sided olive jar. Fill the jar half full of water. Tip the bottle and very *carefully* pour 2 to 3 inches of alcohol on *top* of the water. *Carefully* place the bottle upright on the table. With a medicine dropper transfer some motor oil drops to the bottle. Since the oil drops are heavier than alcohol and lighter or less dense than the water, you can get the motor oil 'planets' in suspension.

By gentle circular agitation it is possible to make the planets orbit.

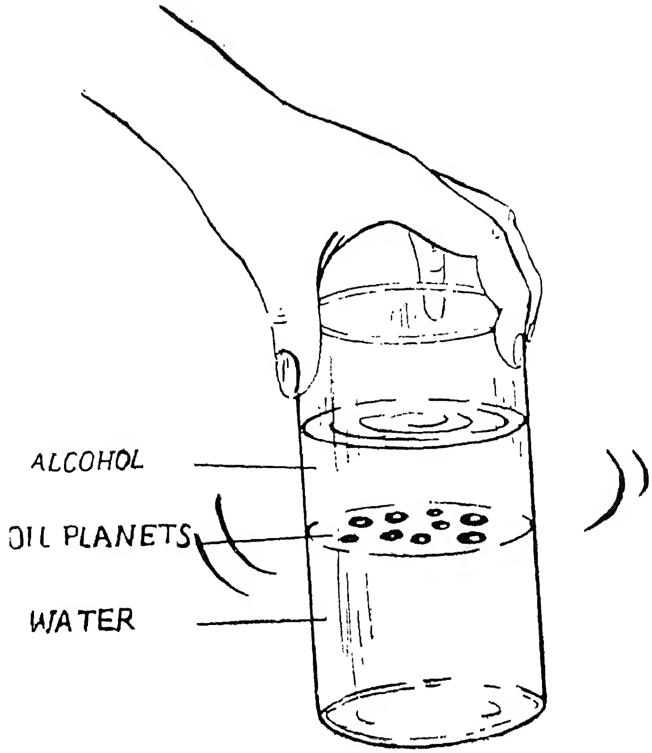


Fig. XIII.2. Demonstration of planets in orbit.

Concept 1-b (p. 121):	Each planet revolves in its own orbit around the sun and also rotates on its axis.

1. Make a hole in a large seed or a round rubber or wooden object (a rubber one-holed cork is good for this). Tie a stout string on it and slip in through an empty spool which helps control the string. Tie a small weight to the end of the string you put through the spool. Whirl it over your head. When does it stop moving in a circular path (orbit)? Is it when you slow down?

All the planets orbit around the sun. Review what you know about orbiting. Does the distance of the planet from the sun tell you anything about their speed? Which planet do you think goes fastest? Shorten the string on your planet demonsstrator. This represents Mercury, nearest the sun. Now let the string lengthen out. This is Pluto, farthest from the sun. What are the comparative speeds or revolution? Now check with the chart Table XIII.2. Were you right in your assumption that the nearer the sun, the faster the planet revolves?

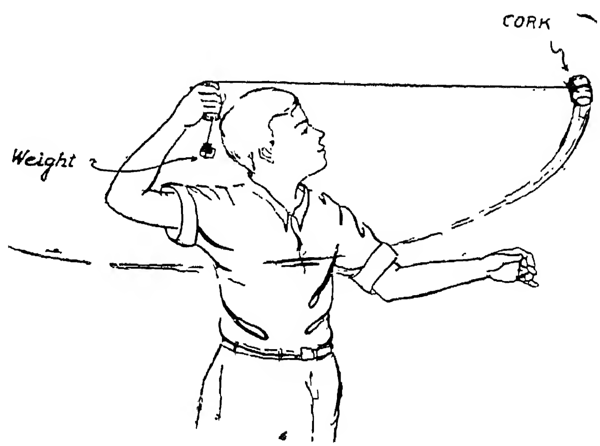


Fig. XIII.3. Model to show orbiting.

TABLE XIII.2. INFORMATION ABOUT THE PLANETS

Planet	Size: Diameter in miles	Size: Compared to Earth	Distance from Sun in miles	Moons	Length of day in Earth time	Length of year in Earth time
Mercury	3,100	$\frac{1}{17}$	36,000,000	0	88 days	88 days
Venus	7,700	$\frac{9}{10}$	67,000,000	0	uncertain	225 days
Earth	7,913	—	93,000,000	1	24 hours	356¼ days
Mars	4,216	$\frac{1}{7}$	142,000,000	2	24½ hours	687 days
Jupiter	86,700	1,318 x	483,000,000	12	10 hours	12 years
Saturn	71,500	736 x	886,000,000	9	10¼ hours	29½ years
Uranus	32,000	64 x	1,780,000,000	5	11 hours	84 years
Neptune	28,000	60 x	2,800,000,000	2	16 hours	165 years
Pluto	about same as earth	about same	3,700,000,000	none known	uncertain	248 years

2. Make a working model of the sun and the planets. One way is to use tinkertoys. (Tinkertoys are wooden construction toys with discs, dowel sticks, etc., for fitting together.) Make the earth model movable so that you can demonstrate its rotation as it moves about the sun.

Concept 1-c (p. 121): Objects revolving around planets are called moons or satellites.

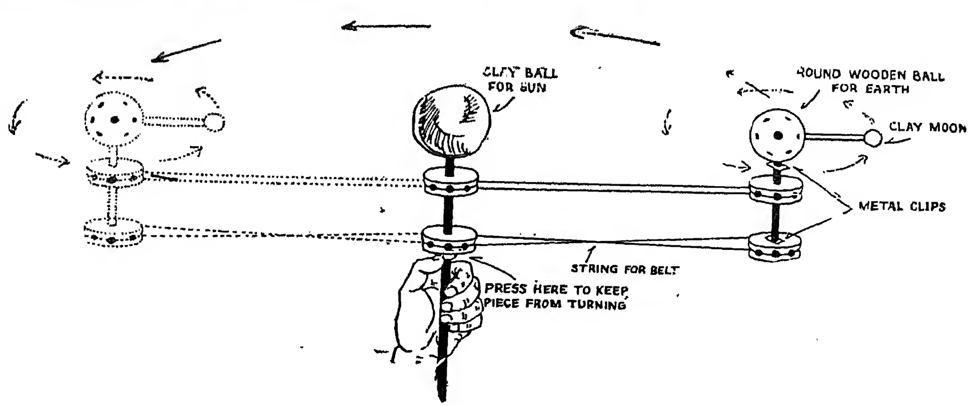


Fig. XIII.4. 'Tinkertoy model solar system.'

1. Look up the meaning of the word *satellite.* It comes from the Latin meaning, 'attendent'. Can you see why moons are called satellites?

Find out what you can about the satellites, or moons, of various planets. Are some larger than others? Some have been suggested for

landing places by space ships. Check on Mar's moons.

2. Read the history of the discovery of four of Jupiter's moons by Galileo. Before his time no one thought of any planet except earth having a moon.

Concept 1-d (p. 121): There are also asteroids, meteors and comets in the solar system.

1. Read about and find pictures showing the *planetoids* or *asteroids* that have been discovered between Mars and Jupiter. How do you think they were discovered? Some 1500 of them, varying in size from small pieces of rock to objects 450 miles across, have been photographed through telescopes. As planets and planetoids move around among the stars, discuss how you think they can be spotted. There are still many more planetoids to discover.

2. Have you seen a *meteorite* in a science museum? A meteorite is a meteor that has come through earth's atmosphere. Rub your hands fast together to give you an idea of what happens to a meteor (piece of rock or metal) moving against the molecules of air in the earth's atmosphere. Most of the *meteors* get so hot in this process that they burn up. You may have heard of meteors called 'shooting stars'. We see a shining light just before they burn up. Find out in the almanac or in a science magazine or the newspaper when the next 'shower' of meteors may come. These showers of meteors occur at particular times of the year. Try early January, early May, mid-August and mid-December. A keen observer on an average clear night can spot some 10 meteors an hour. Why not try? Some scientists think these 'showers' occur when earth passes through a comet's path. Most scientists think meteors are associated with comets. You can become a meteor observer because no optical instruments are needed.

3. Ask yourself these questions. How are meteors formed? Are the debris left over when

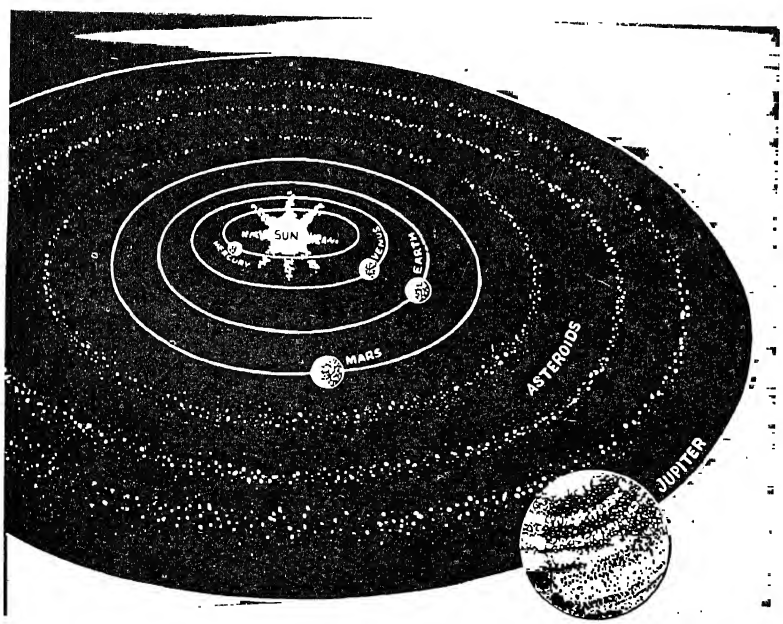
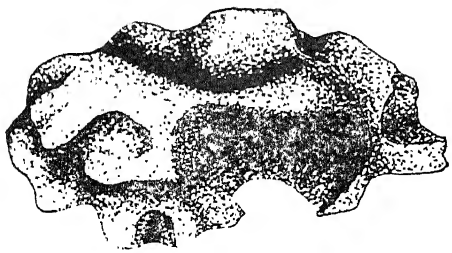
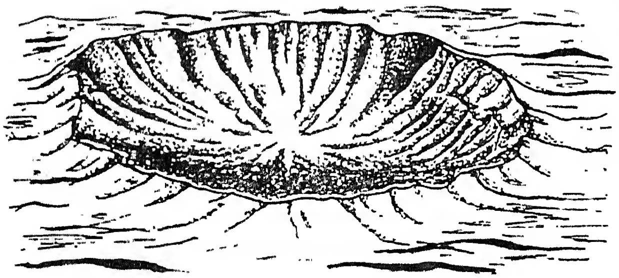


Fig. XIII.5. Asteroids between Mars and Jupiter.

the planets were born? How did the planets come into being? The illustration shows a meteorite, a meteor fragment which has landed on earth, and a crater made by such a landing. Find out more about meteors.



(a)



(b)

Fig. XIII.6. (a) A meteorite (b) A meteorite crater.

4. If you see a fast moving flash in the sky, you will know it is not a *comet*, for comets travel rather slowly in the heavens and their path can be plotted.

Comets are made up of small, solid particles enveloped in gas, while the tail also is made up of gas. So a comet is not like a planet. Find out all you can about comets. Be sure the material you read is of recent origin. In 1986 you will be able to see the famous Halley's Comet which returns once in every 76 years. In fact, astronomers know exactly were it is now, though it cannot be seen for years.

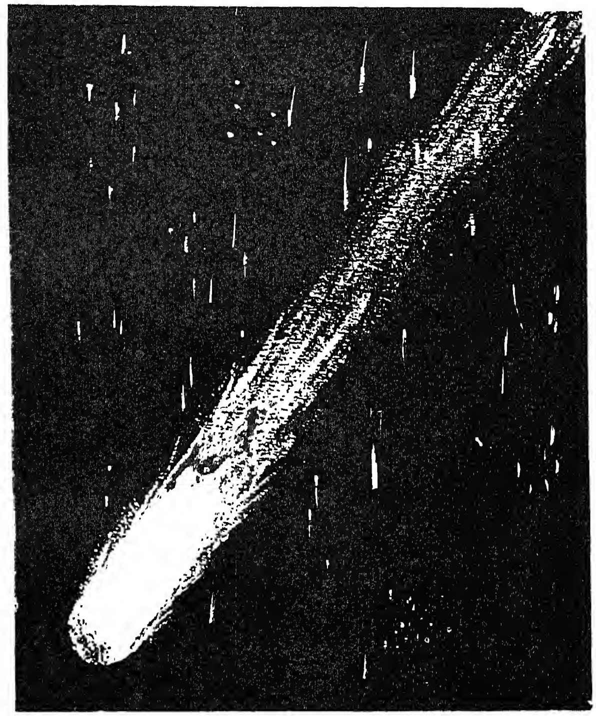


Fig. XIII.7. A comet.

Find out about the elliptical orbits of comets. Draw an ellipse, see how it differs from a circle. You can try this with two pins, a piece of heavy paper and an 8 in. loop of string. (Fig. XIII.8.)

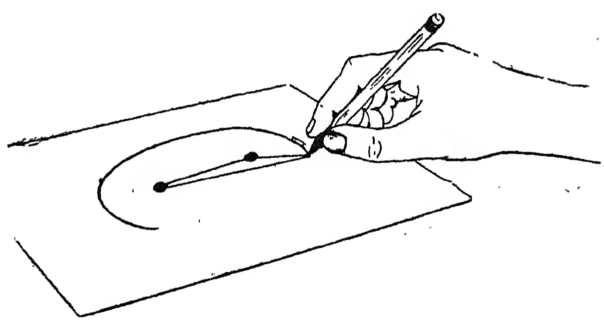


Fig. XIII.8. Draw an ellipse.

A comet can be seen only as it comes near the sun. Why? Does a comet travel head or tail first, or neither at all times? One of the recent comets was discovered by a 13-year old boy. Why don't you become a sky observer?

Concept 1-e (p. 121): Different planets are of different sizes.

The size of objects in the sky is difficult to visualize. Through various devices, demonstrate that huge objects far away may look small and small objects near, may look large.

Draw or make some planets to scale. This can be done by using blown-up balloons and covering them with *papier mache*. The following recipe may be useful.

1. Mix two parts of flour and one part of salt with water until a paste is formed.
2. Inflate the balloon to the desired size.
3. Cover the balloon with several layers of strips of newspapers which have been dipped into the paste.
4. Allow the newspaper covering to dry completely. Then paint the sphere with tempera paints.

These diameters may be used to show the comparative sizes of the planets.

Sun	5 feet	Jupiter	$6\frac{3}{4}$ inches
Mercury	$\frac{1}{4}$ inch	Saturn	$5\frac{1}{2}$ inches
Venus	$\frac{5}{8}$ inch	Uranus	$2\frac{1}{2}$ inches
Earth	$\frac{5}{8}$ inch	Neptune	$2\frac{1}{2}$ inches
Mars	$\frac{3}{8}$ inch	Pluto	$\frac{1}{4}$ inch

You may wish to illustrate the sizes of planets by using familiar objects. They will only approximate to the sizes of objects mentioned against them.

Sun	— A gigantic balloon	Jupiter	— A basketball
Mercury	— A marble	Saturn	— A soccer ball
Venus	— A tennis ball	Uranus	— A baseball
Earth	— A tennis ball	Neptune	— A baseball
Mars	— A ping pong ball	Pluto	— A marble

Concept 1-f (p. 121): The planets are all made of about the same materials as the earth.

Find out the present theories of how planets were formed. As you read, figure out how a scientist uses evidence to explain the origin of our solar system.

Concept 1-g (p. 121): The planets shine by reflected light from the sun.

Imagine what earth would look like from Mars if there were no sun. To find out how objects shine by reflected lights, darken the room and have someone hold a torch so that it points toward his face. His face is lit up, but other faces are in the dark. They do not produce light, nor do planets, moons, planetoids, meteors, or comets. All of them shine by reflected light. Why are some objects brighter than others?

Major Concept 2. The moon travels round the earth as the earth travels round the sun.

Concept 2-a,b (p. 121): (a) The same face of the moon is always visible from the earth. The moon rotates once on its axis as it revolves around the earth.

(b) The period of one rotation of the moon on its axis is about $27\frac{1}{3}$ days. This period is the same as its period of revolution around earth.

1. Why is it we see only one face of the moon? (actually 41% of the moon's surface is never seen from earth).

Act out the motions of the moon. Let one person A be the earth and another B be the moon. Have B turn about on his own axis once.

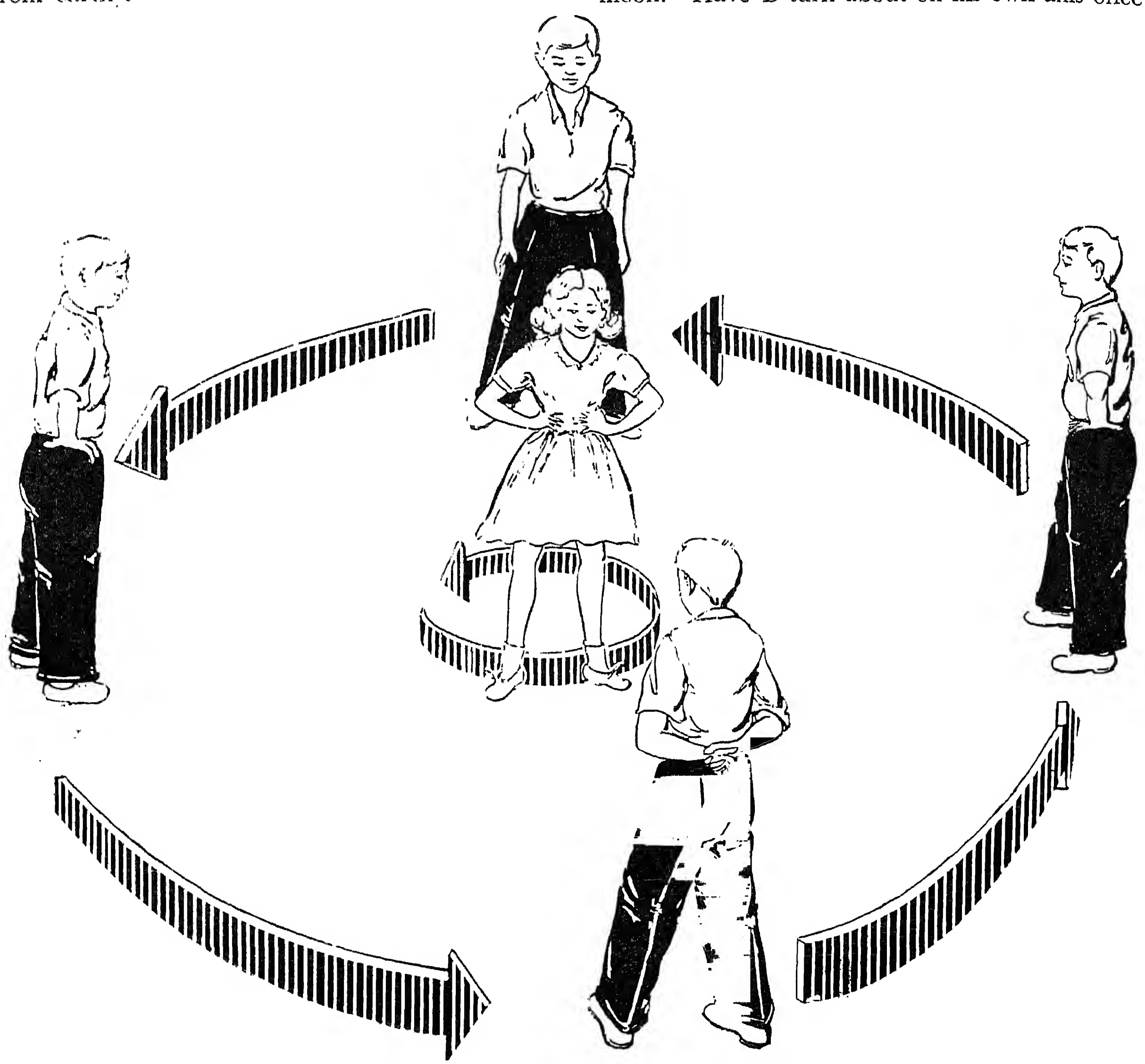


Fig. XIII,9. Movement of the moon and earth.

Now have B walk once around A, always keeping his face toward A. B faces one wall, then another until he has faced all 4 walls during his revolution around earth A. Ask: Did B turn once about on his own axis as he faced all four walls? Did he make one complete turn about A? Did he accomplish both at the same time? The moon also rotates once on its axis as it goes about the earth (revolves). The period of time taken is about $27\frac{1}{3}$ days and we see only one face of the moon.

2. What would one moon day equal in terms of our earth days? (about 15 of our days of daylight, and 15 of our days of darkness).

Concept 2-c (p. 121): The time from one new moon to the next is about $29\frac{1}{2}$ days. It must turn more than one complete revolution to reach the next new moon position between the earth and the sun, for both the earth and the moon have moved eastward along the elliptical orbit.

There are really two kinds of months. If you were to observe the moon from a fixed position in space, such as when it passes a certain star to where it passes again, you will find it takes about $27\frac{1}{3}$ days for the moon to make one *revolution* about the earth while turning once on its axis. (sidereal).

The other kind of month or moon revolution is based on the moon's position from one new moon to the next, or from one full moon to the next. This, you can observe yourself, is $29\frac{1}{2}$ days, or corresponds to our calender month. (synodic).

During this time the earth with the moon has moved what fraction of the way about the sun? (1/12)

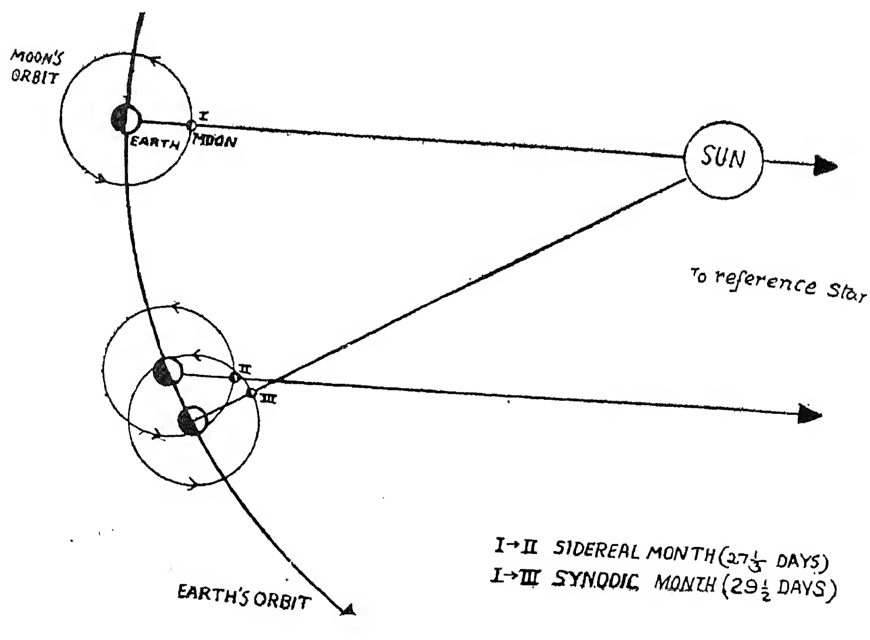


Fig. XIII.10. Sidereal and synodic months.

Plan a movable model to account for this. As a suggestion, draw an ellipse. (Fig. XIII. 8.) Try a movable tinkertoy model of the earth and moon as they move about the sun. Remember in the moon's elliptical orbit, the earth is at one of the pin points. After you have drawn your ellipse you will see that the moon is farther from the earth, at certain times than others.

Try to imagine the three bodies; the sun, the earth and the moon, all moving, each of a different size and mass and at a different distance from each other. The motions of each are influenced by the two. While the moon is circling the earth, the earth is revolving about the sun, carrying the moon with it. So the moon goes around the sun too. Actually the moon and the earth are more strongly influenced by the sun as well as by each other.

Observe the moon at three different times, each an hour apart: say, 6, 7, and 8 P.M.—on any one night. Choose a place where the moon can be seen over the corner of a building, or over a telegraph pole or some similar object. Stand at the same place each time. If the moon seems to move, you can tell in which direction. Keep a record stating the time and position of the moon. The moon seems to move. Is this motion you observe due to the rotation of the earth or the movement of the moon in its orbit? Keep a record stating the position of the moon on successive nights at the same hour as 8 o' clock. The moon appears to move eastward against the background of stars. This eastward motion is due to the movement of the moon in its orbit around the earth.

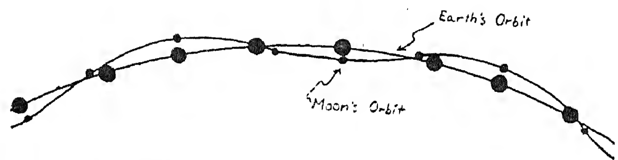


Fig. XIII.11. Earth-moon-sun relationship.

Concept 2-d (**p. 122**): The phases of the moon change as the moon revolves from west to east around the earth.

1. Observe the moon over a period of one month. Draw your observations from the thin crescent in the western sky through first quarter, to full moon in the east at sunset. Then notice that during the next fortnight, the process is in reverse order. Do your drawings show this? Account for the seemingly different shapes (phases) of the moon. How long is it from one new moon (day of the moon) to the next? Actual observation of the moon's movements are far more valuable than models. Models will reinforce learnings only after observations.

2. Set up demonstrations of moon *phases* with balls or *papier mache* models of moon and earth, and a light source (the sun).

(i) An old tennis ball with a knitting needle or straight wire run through for the moon's axis can be moved while the person stands with his back to a strong light. If possible have several

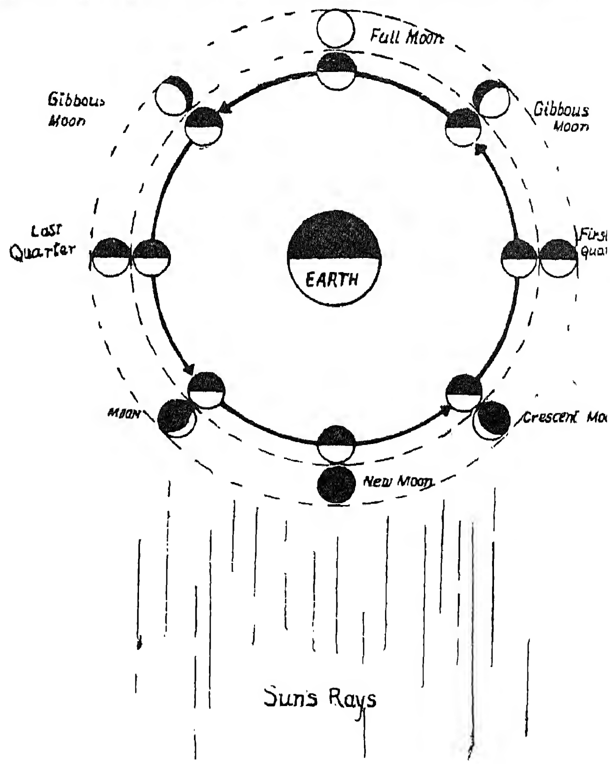


Fig. XIII.12. Phases of the moon.

pieces of apparatus, so that all can experience this.

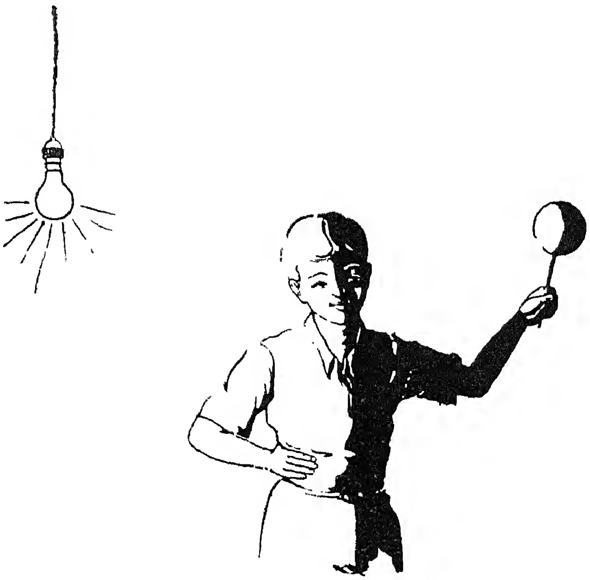


Fig. XIII.13. Moon phases.

(ii) To demonstrate the phases of the moon and the earth, set a globe or larger ball on a box in front of a light. One person can hold a small ball (the moon) suspended by a string on a rod. Watch the moon from the direction of earth (the large ball) as the moon is swung slowly around the globe.

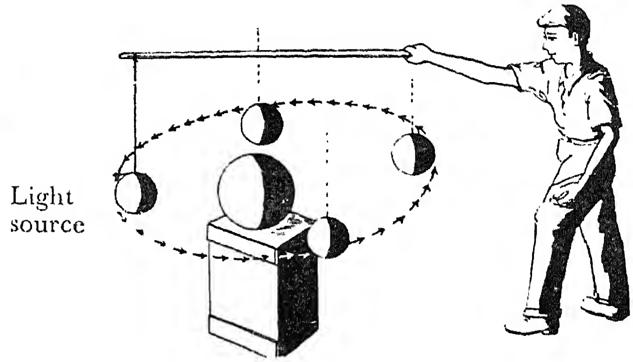


Fig. XIII.14. Another model of moon phases.

(iii) Be sure all the pupils realize that the moon shines only by reflected light from the sun and that its phases are the varying mounts of its lighted side that we see.

Concept 2-e, f (p. 122): (e) The moon travels 12 degrees eastward across the sky every day in its journey around the earth.

(f) The earth rotates once around (360°) eastward each day. This is more than the moon's eastward motion as it revolves round the earth. Therefore, the moon sets in the west. Actually the earth rotates slightly more than once around each day, (about 361°), for it also turns as it goes round the sun.

How many degrees are there in a circle? (360°). If the earth turns once about, plus a little more each day, it is going through how many degrees? How far has the moon gone around the earth in this time? If we take the total time as $\frac{1}{27\frac{1}{3}}$ days, then in one day it has gone $\frac{1}{27\frac{1}{3}}$ of the way. Find out how many degrees it has moved eastward in its journey about the earth. ($\frac{1}{27\frac{1}{3}}$ of 360°, or about 13°.)

You have by now realized that the movements of earth, moon and sun are complicated by a number of factors. Keep up your observations.

Major Concept 3. A satisfactory mental model of the solar system must account for many observable phenomena.

Concept 3-a (p. 122): By building a mental model of the solar system with the earth spinning on its axis, the moon going round the earth, the earth and the moon going round the sun, the earth's axis inclined to the plane of its revolution around the sun, we can account for such observable phenomena as:

(i) day and night.
(ii) sunrise in east, sunset in west.
(iii) seasons.
(iv) phases of moon.
(v) apparent motion of the stars.
(vi) forward and retrograde motion of planets as they revolve round the sun.

How well do you understand the relation of various bodies in space? Test your ideas. Here are some of the motions of heavenly bodies and changes that have been observed by both ancient and modern man.

1. Day and night.
2. Sunrise in the east, sunset in the west.
3. Seasons.
4. Phases of the moon.
5. Apparent motion of the stars.
6. Forward and retrograde (backward) motion of the planets as they revolve around the sun.

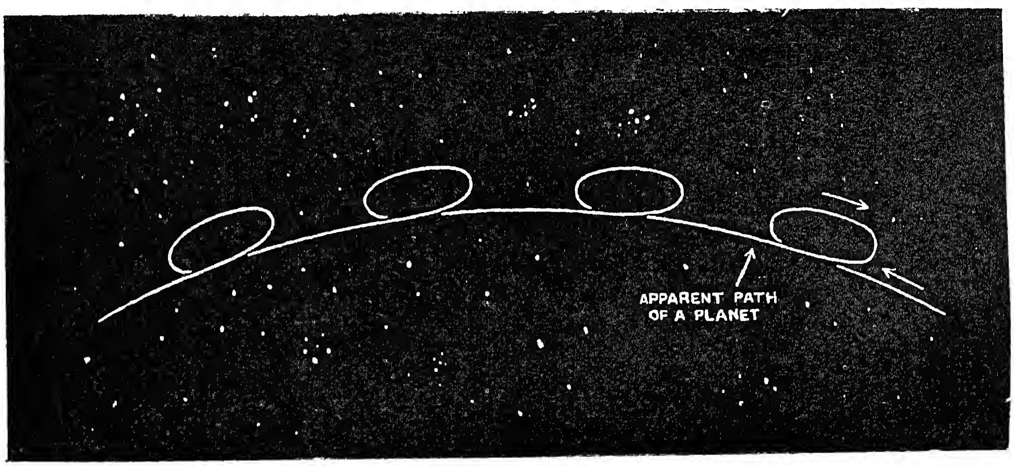


Fig. XII.15 . Apparent motion of the planets.

1. How many of these can you account for by having a motionless earth as the centre of the solar system, as Ptolemy thought, with all else revolving about it?

You should test yourself about *apparent* motion. Did you ever ride southward on a train, while walking back (northward) to a rear car or a different seat ? You are moving northward *relative* to the train moving south. So, relative to the train, you move northward. In much the same way, the sun, moon and planets relative to the distant stars, appear to move eastward.

2. Find out more about Ptolemy's theory.

According to his theory the sun went around the earth once a day. Do you see how he explained day and night? For 1400 years this theory was accepted. People were loath to put the earth anywhere, except at the centre, but soon more accurate observations, especially of planet movements, (the retrograde movement was not the same year after year), made it obviuos that Ptolemy's theory was wrong.

5. Find out what Kepler discovered—that planets do not travel in circular orbits. He found the planets travelled in ellipses. Draw an ellipse (see Fig. XIII.8) and see for yourself that planets will have to travel more rapidly when near the sun than far from it. Kepler's laws grew out of evidence from his observations. Study all his laws.

6. Stretch your imagination by trying to explain the six items under 3-a. Begin by thinking as Brahe did that perhaps the sun and the moon go around the earth, but the other planets go about the sun. Or perhaps you would like to imagine Venus or Jupiter at the centre. Do you agree that the simplest explanation that explains all known facts is the best?

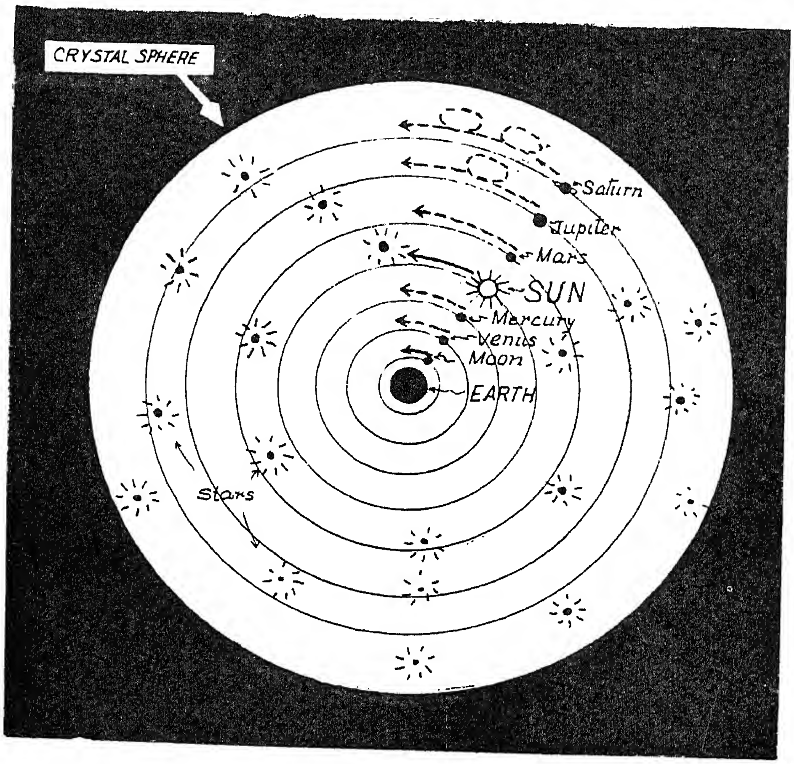


Fig. XIII.16. The Ptolemaic system.
The planets supposedly travelled around the earth in a series of loops, while the sun and the moon had circular orbits.

3. Find out about Copernicus and his new theory, that it would be much simpler to explain movements of celestial bodies if the sun were at the centre of the solar system with the earth rotating and revolving. Why didn't he dare publish his theory?

4. It took experimenting and significant improvements in astronomical instruments to prove Copernicus' theory. Read about Tycho Brahe's observatory, or visit one of Jaisingh's observatories and find out how the various instruments worked.

7. Go back now and construct a mental model of the movements of your solar system. Is your theory adequate to explain all six items by

having the earth rotating on its axis, the moon and earth and other planets going about the sun and the earth's axis inclined to its plane of revolution around the sun? Think of all the years of men's study and observations that have gone into making a theory to account for these observable phenomena.

Additional Activities:

1. Some questions you may wonder about: Why is it that each month when the moon is exactly between the earth and the sun at the moment of a new moon, there is not a solar eclipse?

2. When the moon is behind the earth (full moon), how can the sun illuminate it at all? Why doesn't the earth's shadow hide it completely?

To answer these questions construct a model of the moon's orbit around the earth in relation to that of the earth's orbit about the sun. The moon's orbit is tilted at about 5° to that of the earth, so that sun, moon and earth fall into a straight line only occasionally.

3. When this happens, an eclipse occurs. If you were on the moon, would the earth appear to go through phases too? Explain.

1. What is the origin of lunar craters?
2. Are the seasonal changes on Mars due to annual growth of vegetation?
3. What causes the strong bursts of radio waves on Jupiter?
4. Does volcanic activity occur on the moon?
5. What is the nature of the markings on the surface of Mars?

Major Concept 1. The planets appear to migrate among the stars.

Concept 1-a **(p. 122)****:** The planets move from west to east as they revolve around the sun.

1. Possibly you have made a model or chart of the solar system. A working model gives you some idea of how all the planets have orbits nearly in the same plane, and how they all move in the same direction as the planet earth.

2. Take a phonograph record. Turn it about on a turntable or a pivot of some sort. This will give you an idea of the plane of revolution of the planets, except Pluto. Study the accompanying chart. (Fig. III.17.)

3. Go out with interested friends in the evening to study the planets. Before going, study an almanac to find out how to locate the various planets in relation to the constellations. Then make a chart and observe this planet during at least three months. You can determine for yourself how the planets move. As you watch from evening to evening, do they ever appear to move westward (backwards)?

4. If possible, visit an observatory to look through a telescope or obtain some slides of the planets from an observatory or department of astronomy.

No study of astronomy will be complete

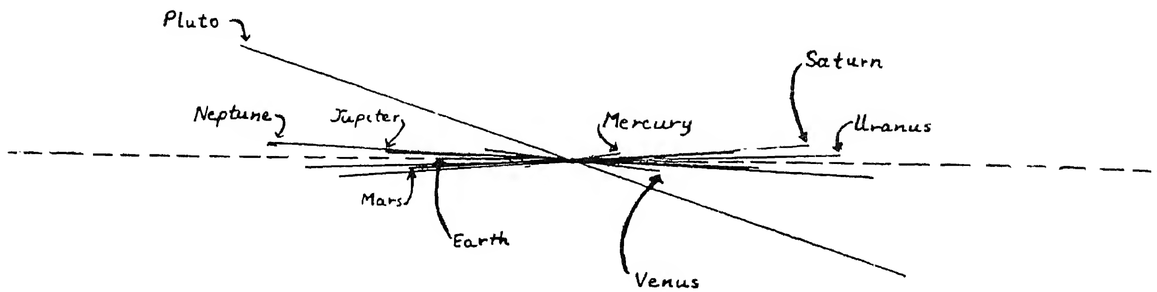


Fig. XIII.17. Plane revolution of the planets. These are the orbits of the planets as viewed from the side. They lie in almost the same plane.

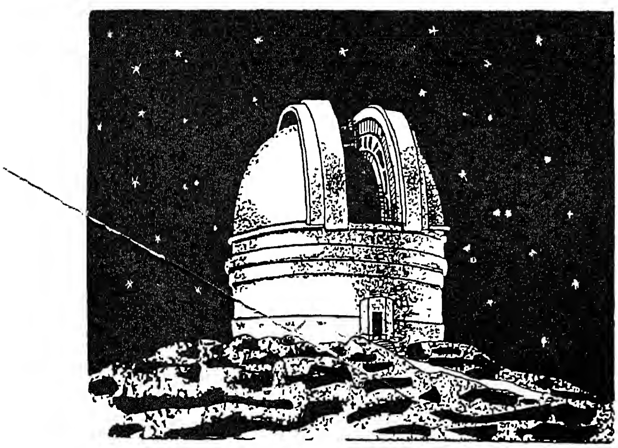


Fig. XIII. 18a. A modern observatory.

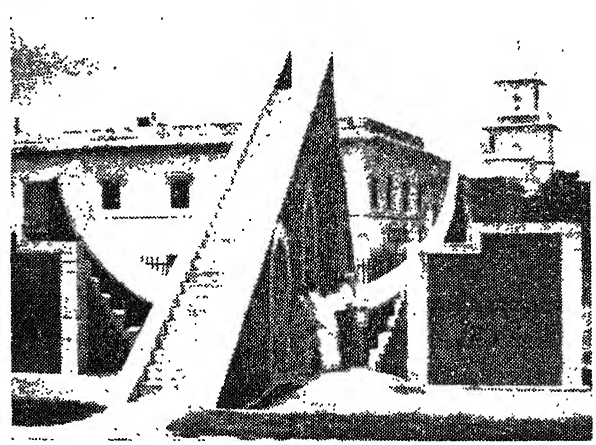


Fig. XIII.18b. Jaisingh's Observatory, Jaipur, 1731.

without mention of the work of Jaisingh of Jaipur (1686 1743). His five great observatoies are among the most remarkable sights in India. The photo is of the *Samrat Yantra*, a huge sun dial. (Fig. XIII.18b) With axis parallel to the earth's axis this is used to determine the time of day by the shadows cast on a huge semi-circle. It is used also to determine the altitude of the sun at noon. One can only marvel that this was built in 1734 and still is functioning with its many astronomical instruments.

Concept 1-b, c p. 123 : (b) Due to the earth's shift in position as it revolves around the sun, the planets appear to move westward periodically among the stars—that is, to show retrograde motion.

(c) Due to the earth's shift in position as it revolves around the sun, and due to the fact that the intensity of light varies inversely to the square of the distance from the source, the planets appear brighter at the time they are showing retrograde motion.

If you closely observe a planet among the stars over a period of months, you will no doubt think it moves backwards at times. But planets do appear to move westward or backwards at times. If we think of their paths as orbits, then in the middle of this backward motion, the planet looks brightest.

Try to show by a diagram of successive positions of the earth and Jupiter as they go around the sun, that at times Jupiter would appear to move westward among the stars. Find out how the Greeks explained it by means of epicycles. You recall Ptolemy's theory that the earth stands still and all else moves about the earth as the centre. To get your bearings with a moving earth, walk in a circle around a stationary object such as a tree or pole or tower. As you move about the circle, this object looks as if it is moving constantly against a different background, but it really is not moving at all. You know that all the planets move about the sun against a background of stars. In your model of the solar system can you see why the earth, being closer to the sun, moves faster than Mars, and so occasionally Earth overtakes Mars. Try drawing your idea of this. How would Mars look as you passed it? It would appear to be moving the other way.

Try this: Get a friend to hold an electric torch about five yards in front of you. Tell him to start walking away very slowly pointing the

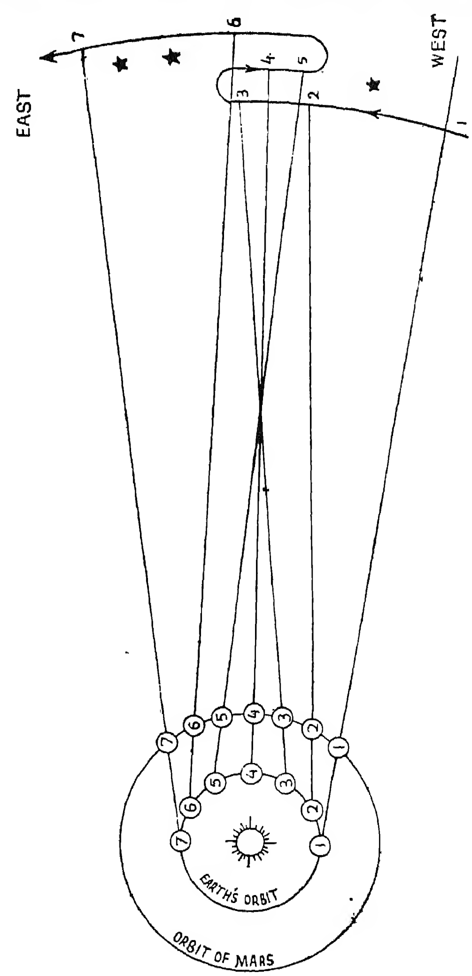


Fig. XIII.19. Apparent motion of Mars in relation to earth.

torch towards you. Meanwhile you start walking fast in the same direction so that you pass near him. What happens as you go? You have to look backwards to see the torch and when you pass it the torch seems brightest. Why? (You are nearest to it at this time, are you not?) Study Fig. XIII. 19 and compare it with your drawing of how it appeared to you.

Major Concept 2. The size and distance of objects may be measured indirectly. Parallax is the basis of all such measurements.

By referring to Table XIII. 2 you will see that it takes Mars almost two earth years to make one revolution around the sun. So when the earth and Mars are on the same side of the sun, Mars appears to be moving backwards (westward) among the distant stars. You have observed the apparent backward motion of trees along the roadside with reference to the distant trees in a woods.

Concept 2-a,b (p. 123): (a) The height of a tower may be measured by comparing the length of its shadow with the length of a shadow of a pole of known length. The height is calculated as follows:

(b) Height of tower is to Height of pole as Length of shadow of Tower is to Length of shadow of pole.

You can measure the circumference of the earth as Erastosthenes did in 650 B.C. He found that the angle of the sun's rays, which were directly overhead at Syene, Egypt, came at an angle of 7.2 degrees at Alexandria, 490 miles north of Syene. From this he reasoned that the distance of 490 miles between Syene and Alexandria represented an arc of a circle with the earth at its centre, and that this arc represents 1/50 of the circumference of a circle ($360/7.2=50$). Therefore the circumference $=50\times490$ miles $=24{,}500$ miles.

1. You remember how to measure things *directly*. 'This is a metre long.' 'That weighs a kilogramme'. 'My friend is five feet four inches tall'; or you may use the metric system to say these things. You use rulers, tape-measures, and scales to make these measurements. How would you measure the height of a tree, the height of the Qutab Minar? You admit that you can't easily measure these by taking a tape measure to the top.

2. How are measurements like these made? Compare the shadow of a pole of known height, such as a yard stick, with the length of the shadow of a tower. Is the tower shadow 20 times that of your yard stick? See if you can compute the height of your tower. You may have learned in geometry that corresponding sides of similar triangles are proportional. Let us set up our proportion.

Since we know ab and bc and have estimated BC, it will be easy to find AB, or the height of the tower. Use this method to measure the height of something in your neighbourhood or on the school grounds. It is fun to use your arithmetic in a science experiment.

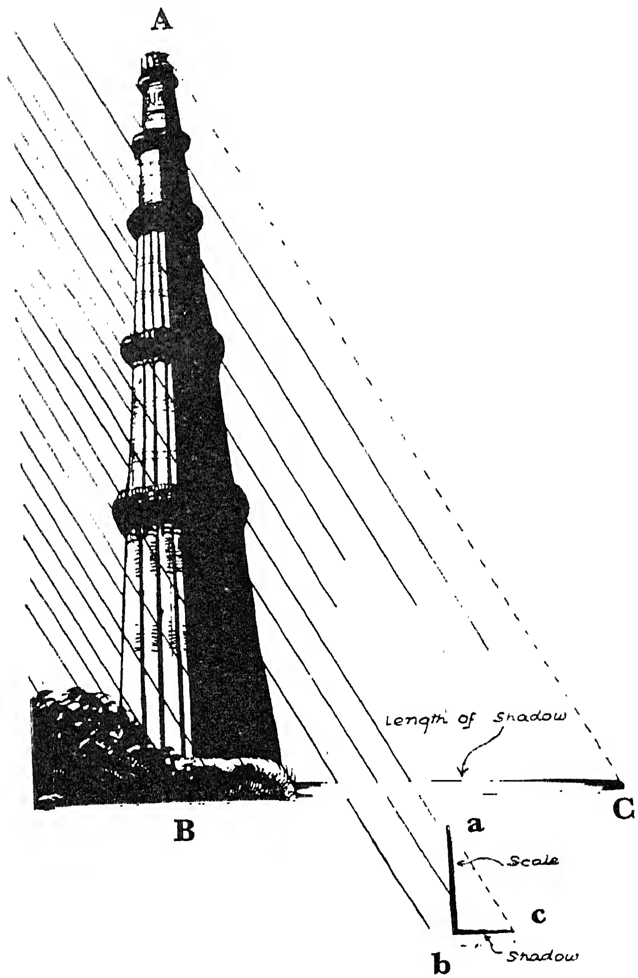


Fig. XIII. 20. Measuring heights indirectly.

$$\text{Height of Tower} = \frac{\text{Height of scale} \times \text{Length of shadow of tower}}{\text{Length of shadow of scale}}$$

3. Can you imagine trying to measure the circumference of the earth by stretching a measuring tape around it? This would be the direct method. Find out how Erastosthenes did it in 650 B.C. How many years ago is this? What information was available to Erastosthenes? He knew something about the direction of the sun's rays in two cities 490 miles apart, Aswan and Alexandria. He measured the angle of the slanting rays in Alexandria on the same day he knew the rays

were straight overhead in Aswan.

Imagine lines drawn directly into the centre of the earth from these two cities. Recall the angle of the slanting rays and find the other equal angle. What is the relationship of 7 1/5s to the degrees in a whole circle? (answer 1/50). See how important your mathematics is? Now he knew the distance between the two cities as 490 miles, so 490 miles = 1/50 of the total circumference. Therefore the circumference is 50 × 490 miles or 24,500 miles. (See Concept 2-b.)

4. What is the relationship of the earths' diameter, 8,000 miles, to its circumference? Try this: Take the measurement of something circular like a large can, waste basket, or a wheel. Use a string if you don't have a tape measure. Then measure the distance across, the diameter, of the

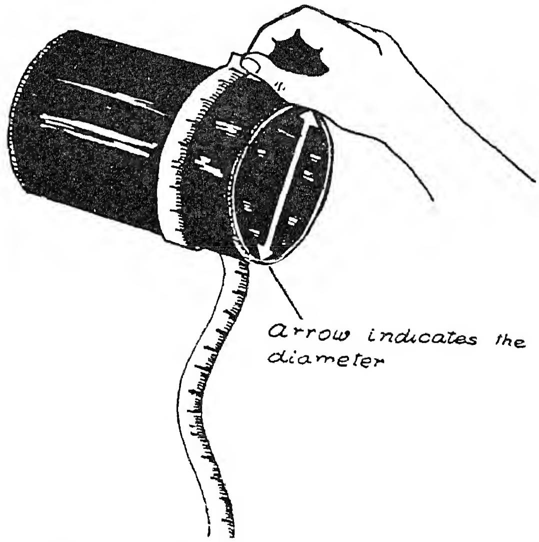


Fig. XIII. 21. Direct measuring of circumference.

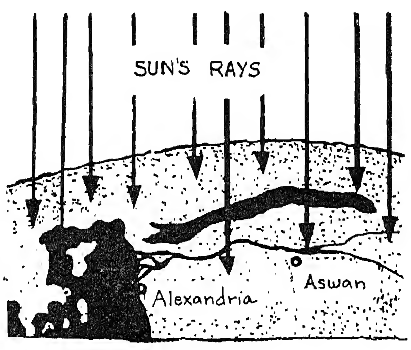
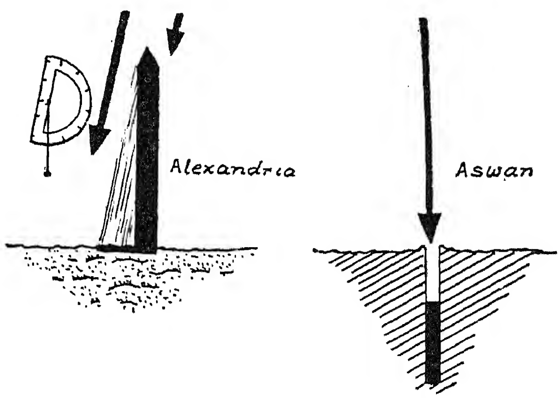


Fig. XIII.22. Noon at Aswan and Alexandria.



How Erastosthenes determined the earth's circumference

can, basket, or wheel. Divide the circumference by the diameter or show the relationship on your string. If you were very careful you will get an answer 3.14 or 3 1/7. This number you know as 'pi' (π)."

It is surprisng, isn't it, that even today scientists use Erastosthenes' method. Surveyors use his idea of how far you must travel on the surface of the earth to make an angle of 1° at the earth's centre. You have learned that this is about 69 miles, but is it not interesting to know how men learned it to be true?

How did surveyors find out that 69 miles on the earth's surface makes a 1° angle at the centre? Find out more about indirect measurement.

Concept 2-c (p. 123): The apparent change of position against background objects is called parallax.

(i) As you move along a highway, the trees near you seem to shift with respect to the trees in the distance.

(ii) A pencil held at arm's length appears to shift its position with respect to the opposite side of the room when viewed first with one eye and then with the other.

Try this. Hold a pencil at arms length in front of you. Close one eye and locate your finger. Sometimes it helps to line your pencil up with another object. Now close the sighting eye and open the other. What has happened to your pencil. It can't be. Try it again. The same thing happens. The pencil appears to move. There is an apparent change of position in relation

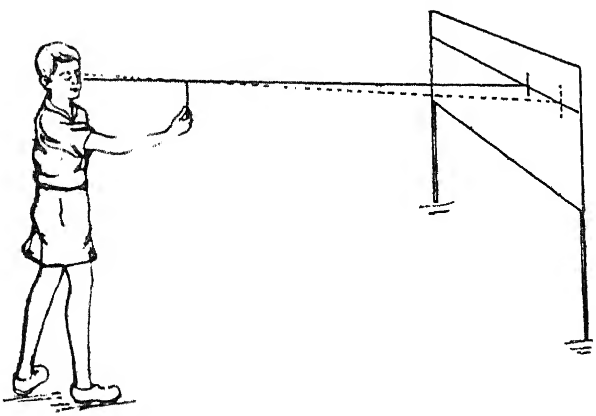


Fig. XIII.23. The parallax effect.

to background objects. This is called the parallax effect. We can use this for indirect measurements.

Now what happens if you ask a friend to hold the pencil and you move back away from your friend, still viewing the pencil with one eye and then with the other. Keep a record of this. Does your record look like this?

Distance from pencil	0 1 2 3 4 5 6 7 8 9 10 11 12	Parallax
3 feet	←——————→	6 spaces
6 feet	←————→	3 spaces
9 feet	←——→	2 spaces
12 feet	↔	1 space

Does parallax increase or decrease with distance? Is there a place where you no longer see any parallax? You use parallax all the while you are noting whether objects are near you or are far away. Did you ever try to close an eye and try to bring two points of pencils together at arms length? You really need parallax to help you. You need two positions for citing the object—your two eyes in this case. You have also discovered that parallax is smaller the farther away an object is.

What will happen if the two positions for sighting are farther apart? You can try this. Punch small holes six inches apart in a piece of cardboard. Have your friend hold a pencil out in front of you. Sight through each hole. Make a record of the parallax. Now record the parallax when you look through holes 1 and 3, 2 and 4 and then through 1 and 4. Check your results by looking at the pencil using only your eyes. What can you say you have found out? Is it this? The greater the separation between the two sighting positions, and let us call this the *base line*, the greater is the parallax. Can you imagine that a long base line would help you to see objects

farther away? Compare what you have done with the use of a range finder as used by military services. This is an artifical way of making the eyes seem farther apart.

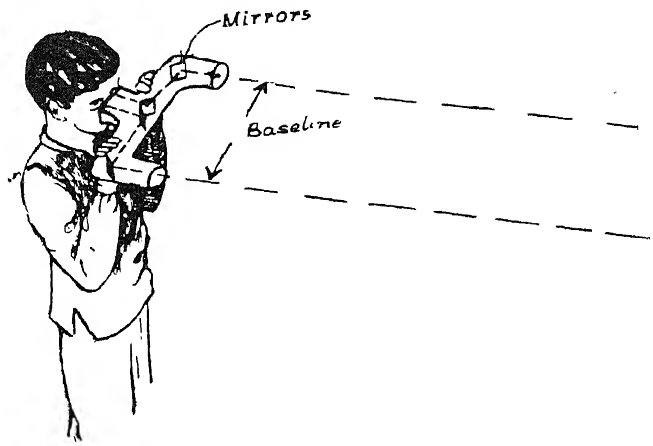


Fig. XIII.24. A Range-finder.

Concept 2-d (p. 124): Using parallax, the distance across a field may be measured. This can be done by staking out a base line and sighting across the field from each end of the triangle. Then a similar triangle is constructed at one end of the base line, and the distance calculated as follows:
Distance across field: Length of base line::
Length of corresponding side of triangle: Length of base of triangle.
Having calculated the distance across the field, it is possible to determine the size of an object there using similar triangle.

Now let us use *parallax*. Fix a known base line in relation to the field you wish to measure across. Sight across the field to a fixed point from the two ends of the base line. How do you determine angle A? How will this help us learn the distance across the field?

If you have a protractor, draw a triangle and measure each of the three angles, adding up the degree. Draw some others, adding up the degrees in each. Do you get 180° total each time? See Fig. XIII.25. What is angle A? You say it is 80°. Now make a scale drawing by using a base line of 4 cm., so that your known base line of 40 metres equals 4 cm. on this scale. You can now measure the distances on your model and figure the distances in the field.

Let us now set up our proportion. The distance across the field: Ac (on our model) : : length of the known base line : length of base line of our scale model triangle. Why is this? Since corresponding angles of similar triangles are equal, and since corresponding sides of the similar triangles are proportional, then by knowing the length of two sides of a small triangle, and one side of large similar triangle, the distance along the long side may be determined.

So—AC : Ac : : AB : Ab

AC^{m} : 12cm : : 40^{m} ; 4cm.

AC= 120 metres

Test this principle out by drawing a triangle and then dividing it up. See illustration. As you study this illustration what conclusions do you draw?

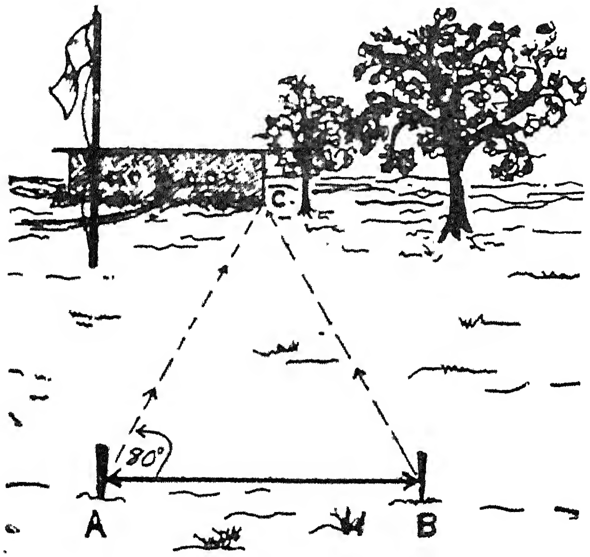


Fig. XIII.25. Indirect measuring across a field.

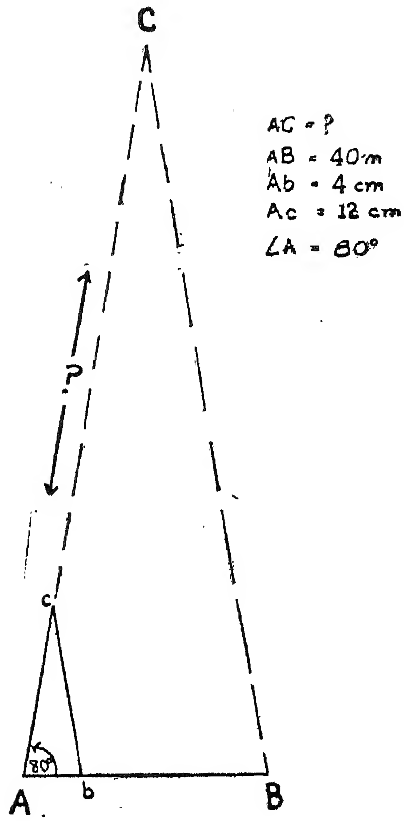


Fig. XIII.26. Indirect measuring across a field.

Concept 2-e (p. 124): The distance to the moon and the planets can be estimated by triangulation.

Suppose you want to measure the distance to the moon. You can do this by similar tringles just as you measured the distance across a field. An astronomer will measure angles with great accuracy and calculate distances by trigonometry. But he could do it by means of similar triangles as is shown in Fig. XIII. 26. You can study this method, and then go to some location where you can sight a great distance from a mountain top or tower, and use this same method in measuring the distance to some nearby object to be used as a base line. (In this case you would consider the light coming to you and your fellow observer from the distant object as parallel light.)

Assume that two astronomers make simultaneous observations on the moon and a distant star. Assume further that these astronomers are located 4000 miles (6400 Km) distant from each other. Assume that they made the observations given in this example. Then they can calculate the distance to the moon as is shown below. (The angular distance is greatly exaggerated in the figure.)

The distance from Stockholm to the Cape of Good Hope is 4000 miles (6400 Km). When the astronomer in Stockholm sights the rim of the moon he sees light from a distant star right at the rim of the moon. At the same time the astronomer at the Cape of Good Hope measures an angle of

1° between the rim of the moon and the same star. The star is so far away that light reaching the two astronomers may be considered parallel light.

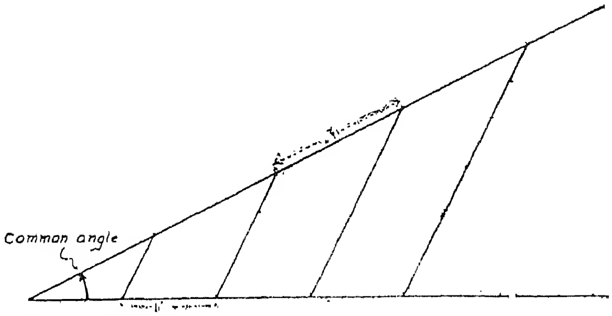


Fig. XIII.27. Corresponding sides of similar triangles are proportional in length; corresponding angles are equal.

To calculate the distances to the moon, the astronomer at Cape of Good Hope draws a triangle carefully with a protractor. The angle subtended at the moon by the distance between the two astronomers is the same as the angle measured by the astronomer at the Cape of Good Hope. So if you draw a triangle with a 1° angle and extend this triangle until it has a base line 5 millimeters in length, you have a triangle similar to the one obtained by the measurements on the moon and the star.

You can calculate the distance to the moon in this way:

$$\frac{5\text{mm}}{4000 \text{ miles}} = \frac{300\text{mm}}{X \text{ miles}}$$

$$5X = 1{,}200{,}000 \text{ miles}$$

$$X = 240{,}000 \text{ miles}$$ (a rather rough figure, but satisfactory for the distance to the moon).

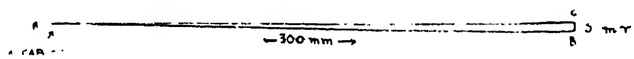


Fig. XIII.28. A 1° angle at the moon subtended by a distance of 4000 miles on the earth's surface.

Concept 2-f,g (p. 124): (f) After the distance to the moon is calculated, the diameter of the moon can be estimated by triangulation.
(g) The distance to the moon can also be measured by the echo or a radar beam.

1. Try to find the diameter of the moon now that you know the distance. Again you can use the relationship of similar triangles. Some night just as the moon has risen over the horizon take a bent paper clip like this. Hold the clip at arm's length and with one eye, sight through the clip points to the moon. Squeeze the clip until the points seem to just cover the width of the moon. Now ask your friend to measure the distance from your eye to the clip. Do you see

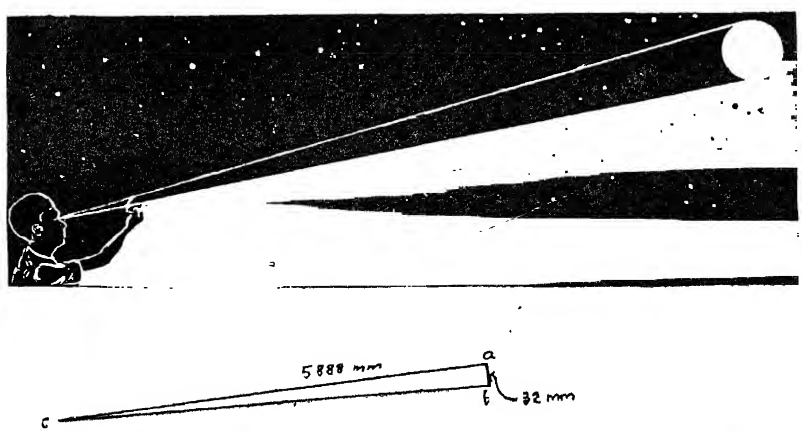


Fig. XIII.29. Measuring the diameter of the moon by similar triangles (1).

the triangle abc formed by your eye and the clip and a similar triangle millions of times bigger is the triangle ABC formed by your eye and the two opposite sides of the moon. If line ab is 32mm. and line ac is 588.8mm then ac is really 184 times as long as ab. Since these are similar triangles, then AC must be 184 times as long as AB. Now we know AC distance is 240,000 miles (384,000 Km), so what is AB? It is 1/184 of 240,000 or 1304 (not very accurate) but perhaps you will try to refine your observations.

2. Try to find the diameter of the moon using another method. Get a yard stick, an electric torch and a pencil. Get a small piece of construction paper. Make a pinhole in it. Attach the paper to the end of your yardstick with a thumb tack. When the moon is nearly full go outdoors with the yardstick. Sight at the moon along the stick through the pinhole until it covers your view of the moon. Read the distance from the pinhole to the pencil. Make several measurements and take the average of your anwsers.

You can easily determine the diameter of the pencil, the distance to the pencil, and the distance to the moon. Find the diameter of the moon. Write your proportion BC : bc=AB : Ab.

Scientists in 1946 beamed bursts or pulses of radio waves at the moon. These waves, hitting the moon, were bounced back to the earth and were picked up by special radar antennae. The scientists knew the speed of radio waves was similar to light, 186,000 miles per second. They found it took radio waves 2.56 seconds for a round trip, earth to moon to earth. Calculate the moon's distance from earth. Distance to the moon—speed of radio waves $\times$time for a one-way trip. What is your answer? (See Fig. XI. 9)

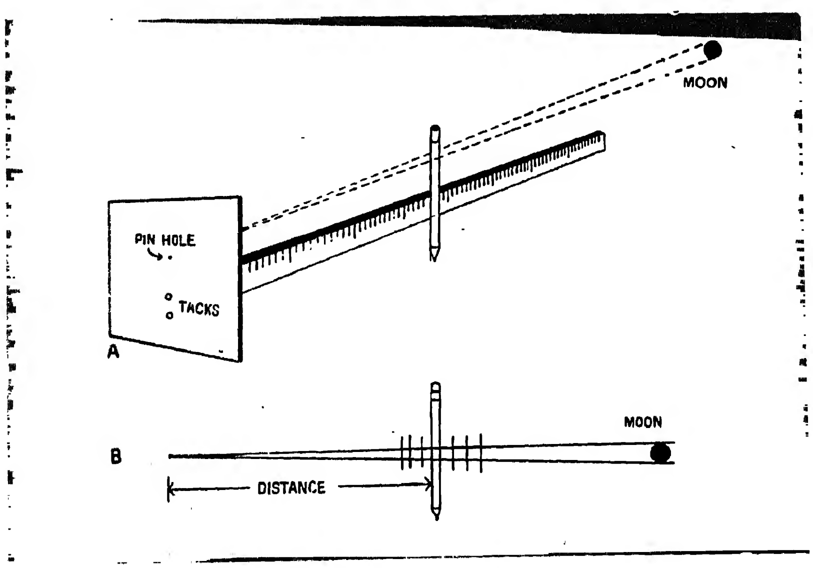


Fig. XIII. 30. Measuring the diameter of the moon (2)

Major Concept 1. The universe includes everything that exists. It is so vast that its limits are unknown. The solar system is located in one of the arms of a local 'pin-wheel' of stars, called a galaxy. Within this galaxy are billions of stars grouped in various ways.

1. Make a time line of the beliefs held about the *universe*. Include the men who gave leadership in developing such beliefs; such as Ptolemy, Copernicus, Brahe, Kepler, Galileo, and others. Reflect on this: Before 1600 A.D. the solar system was believed to be composed of 8 parts: sun, moon, earth and five planets. Galileo with a primitive telescope added 4 more parts, the four moons that he saw around Jupiter. Since that time it has been found that just in one star's (our sun's) family are nine planets, 31 moons, thousands of asteroids following separate orbits, comets, and meteors. Remember we have spoken of but one star, when there are untold billions. Now we know our solar system is just a small part of 'one' *galaxy*: whereas there are many such systems in the universe. (Figs. XIII. 31, 32) Our solar system is not even in the centre of its galaxy.

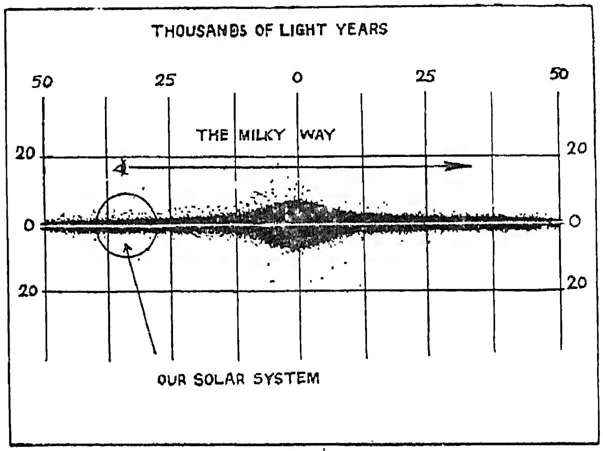


Fig. XIII.32. The Milky Way galaxy (side view).

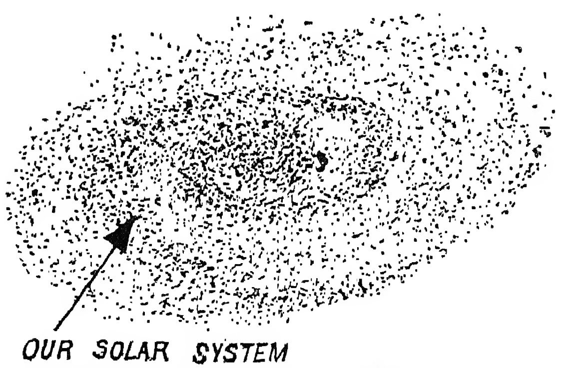


Fig. XIII.31. The Milky Way galaxy (top view).

Our little system of nine planets going round and round our star (sun) is seperated by unimaginable distances from all else in our galaxy, and our galaxy is widely separated from all else in the universe.

2. There are few first hand experiences which can be presented in this area, so reliance must be placed on any available visual aids such as good films, filmstrips, photographs from observatories, and source books, to develop and extend the concepts in this unit. This will be a fruitful area for pupils to do investigation of topics in the library and to do textbook research, after they have been stimulated by good, answerable questions.

3. Encourage continued observation of the the night sky.

4. Utilize any opportunity for use of a telescope.

5. Encourage adults who have developed astronomy as a hobby or a profession to serve as resource persons for the class.

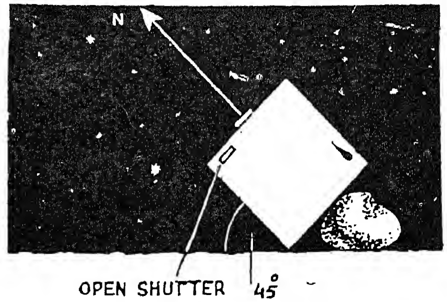
Concept 1-a (p. 124): Stars are far-away suns. They are huge balls of glowing gases.

1. Distinguish between stars and planets. Stars appear as points of light; to some they appear to twinkle. They shine by their own light, whereas a planet has a clear round steady light which is reflected from the sun. Unlike planets, stars appear in fixed positions in the sky.

2. If you can take photographs you can have an exciting experience photographing star trails. You will need to take a timed exposure. Point the camera towards the north star. Expose the film for several hours after sunset and before sunrise on a moonless night. You must do this away from city lights or car headlights. Does your finished photo look like this. (Fig. XIII. 33).

3. Now open wide your shutter and try again. Protect from any outside light like head lights of cars.

4. Purchase a star map, if possible selecting the simplest one for your first study. Secure an electric torch and you are ready to study the stars.



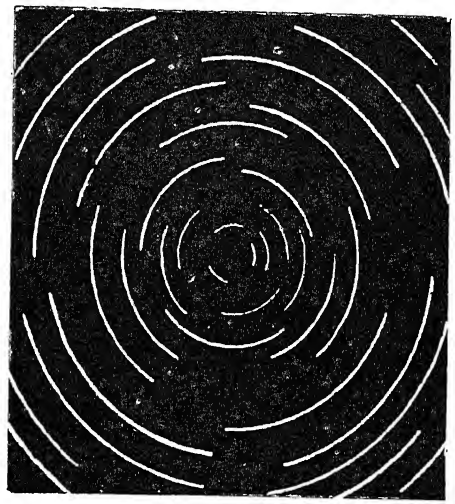


Fig. XIII.33. Star trails.

Concept 1-b, c (p. 124):	(b) Stars differ much in size, colour and temperature.
	(c) The sun is a middle-sized star.

Stars differ in various ways. What sort of messages do we get from the stars? All information of the star comes in a beam of light or by radio waves. A scientist who studies these things, called 'an astronomer,' can measure how bright the light is. He can spread out light to find out its colours, and he can find out from where the light comes.

1. Let us look at some stars. Watching the stars is more fun if you recognize some familiar star groups or *constellations*. If you have found the star groups in the north, such as The Big Dipper, Little Dipper, and others, (see Fig.XIII.34) then face south to find Orion, called the Hunter. Orion is especially clear on a winter night. Remember stars show up better on a clear moonless night. Star maps or almanacs should help you locate it. However, its pattern in the sky should lead you to it. See the three small stars in a row like a belt and others like a sword. Now move your eye up to what might be the four bright stars in the body of a giant warrior. You will see in his right shoulder a red star called Betelgeuse. Now follow down to his opposite knee or where you think the knee should be and there is a blue-white star, Rigel. In Fig. XIII. 34 you will see that the big red star in the right shoulder of Orion along with Sirius, the Dog Star in Canis Major and Procyon in Canis Minor form what is termed the Celestial Triangle in the sky. Later you will know that Sirius is the brightest star in the sky. Learning your way about the sky at night can

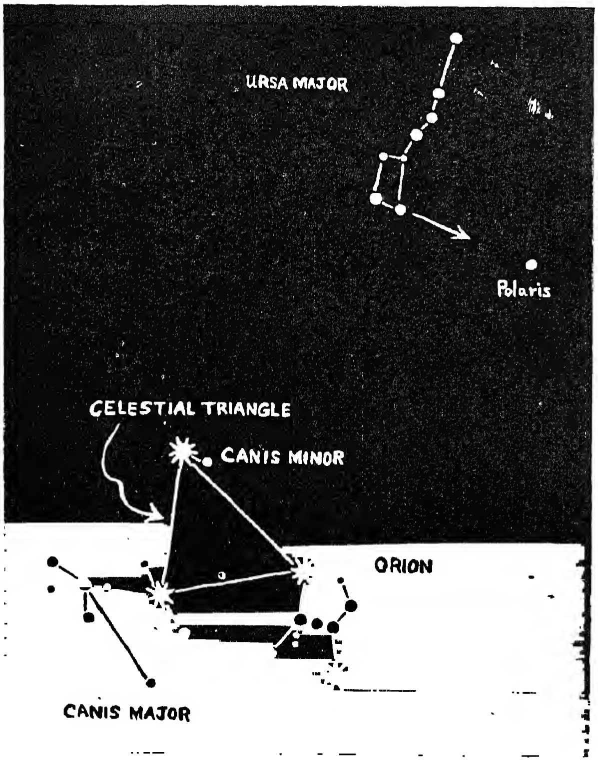


Fig. XIII.34. Orion constellation in the winter sky.

become a fascinating hobby. Although today few people think of lions, scorpions, or hunters in the sky, still we refer to the early names and still read the myths about star groups of the early peoples. Scientists think temperature determines colour. Which is hottest, our yellow sun, the red Betelgehse or blue-white Rigel? Can you find out from what you know about gas or candle flame which colour will be hottest? (Here is a clue; the blue flame is hottest.)

2. How big does an object appear and how big is it actually? Try this. Hold your thumb up to your eye so that you hide someone's head or hold a coin toward the classroom clock. See the difference between how big an object seems and what it actually is.

How big are stars? Something small, close by, may look large; and something big, far away, may appear very small. Does this hold true for stars? Look at any star. It looks like a dot of light. This does not tell us much about its size, its temperature, its actual brightness, or very much about its distance from us. Scientists talk about giants and dwarfs and stars of intermediate size. Recall we found a giant red star in the constellation, Orion. The nearest star to us Proxima Centauri, is a red dwarf. We might think of the red giant as a search light, and the red dwarf as a match light. There are orange gaints and dwarfs also. Study the following Table and answer these questions:

(a) Is there a relationship between the colour and the temperature of stars?
(b) What does this Table tell you about our sun (star)?
(c) Which colour do the hottest stars show? The coolest?

TABLE XIII. 3. COLOURS AND TEMPERATURES OF STARS

Star	Colour (as you see it)	Surface temperature
Rigel	blue-white	40,000°F
Sirius	white	20,000°F
Procyon	yellow-white	14,000°F
Our sun	yellow	11,000°F
Arcturus	orange-yellow	8,000°F
Antares	red	4,000°F

3. Hold a needle or thin piece of picture wire with a pair of pliers over a hot flame. Hold it in the hot part of the flame (recall this?). Watch its glow change from dull red to bright red to orange to yellow as the temperature increases. What colour would you expect if you could raise its temperature still higher? We shall find out later about measuring the temperatures of the stars with a spectroscope.

Concept 1-d p. 124 : Stars are so far away that even though they are moving rapidly, they seem to be in fixed positions.

Does the sun seem far away to you? It is 93,000,000 miles from us, but it appears so bright and big it is hard to realize that it takes light nearly 8 minutes to reach us from the sun. The next nearest star is 26 trillion (2.6×10^{13}) miles away. Write this number? Do a little mathematics and see how many times farther away this is than the sun. Suppose we use, a 1 foot (30 cm.) globe as the sun, then a bead of 1/18 inch, (3 mm.) diameter will represent the earth. Put the globe down on the playground and then measure off 107 feet (27 metres) from the globe. Put earth down there. Now where will you put the nearest star? Over 5000 miles (8000 km.) away is the nearest star on our scale. With these distances in mind, can you see why we cannot see them moving ? Remember they are moving through space.

Concept 1-e p. 124 : Stars have been grouped into handy patterns called 'constellations.' Man uses constellations to guide his movements at night, and to find specific objects in the sky.

1. Teach a younger friend how to locate star pattern in the sky. Show him a star map. He may be surprised to learn that the sky is divided into some 89 *constellations* or star patterns and that these have served as points of reference during man's time on earth and will continue to do so. The 'Dippers' are arranged so that one is upright when the other is upside down and their handles extend in different directions. Notice the pointer stars in the cup of the Big Dipper (Ursa Major). Follow these to the North Star, Polaris. Now extend this line through Polaris an equal distance on the other side. There you will see a W-shaped group, Cassiopeia. Can you believe that the stars in the pattern are millions of miles from each other?

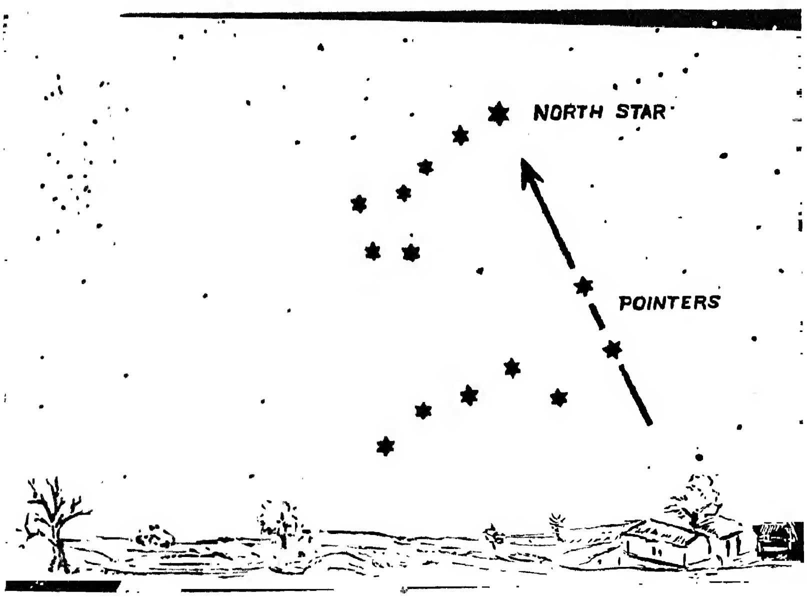


Fig. XIII.35a. Star map showing Big Dipper, Little Dipper and North Star.

Do you see how this might help you to find your direction? You can also locate planets in certain constellations at specified times of the year.

2. Study the chart. Make a star map of your own. Notice that there is a different group of constellations prominent at each season of the year.

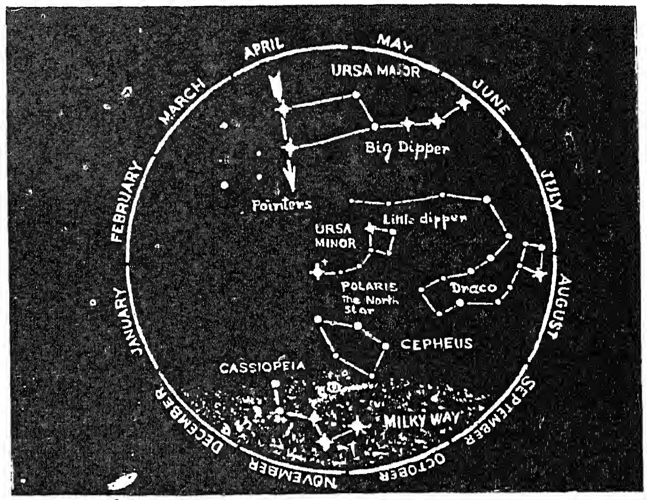


Fig. XIII 35b. Map of the north circumpolar constellation.

Concept 1-f,g (p. 125): (f) Stars may be located by knowing the direction and the altitude in the sky.
(g) Stars are located precisely by a system of co-ordinates similar to latitude and longitude, called 'right ascension and latitude.'

Look at a street map of a city or town or draw one for your town or village, if none is available. Do some streets go north and south, while others go east and west? How would you develop a plan of streets in the sky? Review *latitude* and *longitude*. Now can you see how we can map the sky? In Fig.XIII.36 you will see a navigator using a sextant by which he sights the North Star and lines up the ship's latitude. The men are all pointing at the North Star from different places on the earth's surface. The angle of the arm helps you to determine your *altitude*.

We have already found some reference points such as the North Star (Polaris). How do you suppose ancient men worked out accurate reference points in the sky? They could do it because the stars appear to rise and set and the fact that stars visible in one place were not visible in another. Early man conceived of the sky as a dome, which today we know is not accurate. Suppose we think of the earth as a sphere and the sky as another concentric sphere, a hollow sphere having the same centre as the earth. This hollow sphere is called the *celestial sphere*. As in the case of mapping the earth, parallels are used to measure latitude north and south of the equator. Meridians are used to measure east and west distances. The celestial poles are above the earth's North and South poles. The star, Polaris, is the brightest star nearest the north celestial pole. If you made a good photograph of the star trails of the circumpolar stars, you can find the North celestial pole by finding the common centre of the arcs the stars made. (See Fig.XIII.33.) The corresponding imaginary line between the North and the South celestial poles is the *celestial equator*. You can tell approximately where this equator is by watching the sun on March 21 or September 23. Circles perpendicular to the celestial equator are called *hour circles* and correspond to the meridians of longitude. Directly above the head of the observer is the *Zenith* and exactly opposite is the *Nadir*, or the point directly beneath the observer. At 90°, or half way between Zenith and Nadir, is a horizontal circle called the *celestial horizon*. It is roughly where earth and sky meet. Study Fig.XIII.37

1. A number of systems of locating stars have been worked out. A simple way to locate a star is by altitude above the horizon and by direction. Can you estimate the altitude and direction of some star? How does a surveyor use a transit? Find out how navigators use stars for locating places. What is a marine sextant? Can you get a Navy man to explain it to you? (Refer to Fig. XIII. 36.)

2. Find the latitude of your home. Make a latitude finder yourself. It will not be as accurate as a sextant but is easier to make (Fig. XIII. 38). Nail two short pieces of wood together to make an angle. If you cannot get a protractor, make one. Place the protractor as shown in the figure and drop from it a string from which hangs a small heavy bolt or weight. Aim your latitude finder at the North star across the heads of the two nails you set in the longer angle piece. Then mark the place where the string touches the protractor. This reading will be your latitude on earth. Like a good scientist repeat your readings several nights. Do they vary? Compare your answer with that in an almanac. Do some imagining about the celestial sphere. Can you think of a way to locate a star?

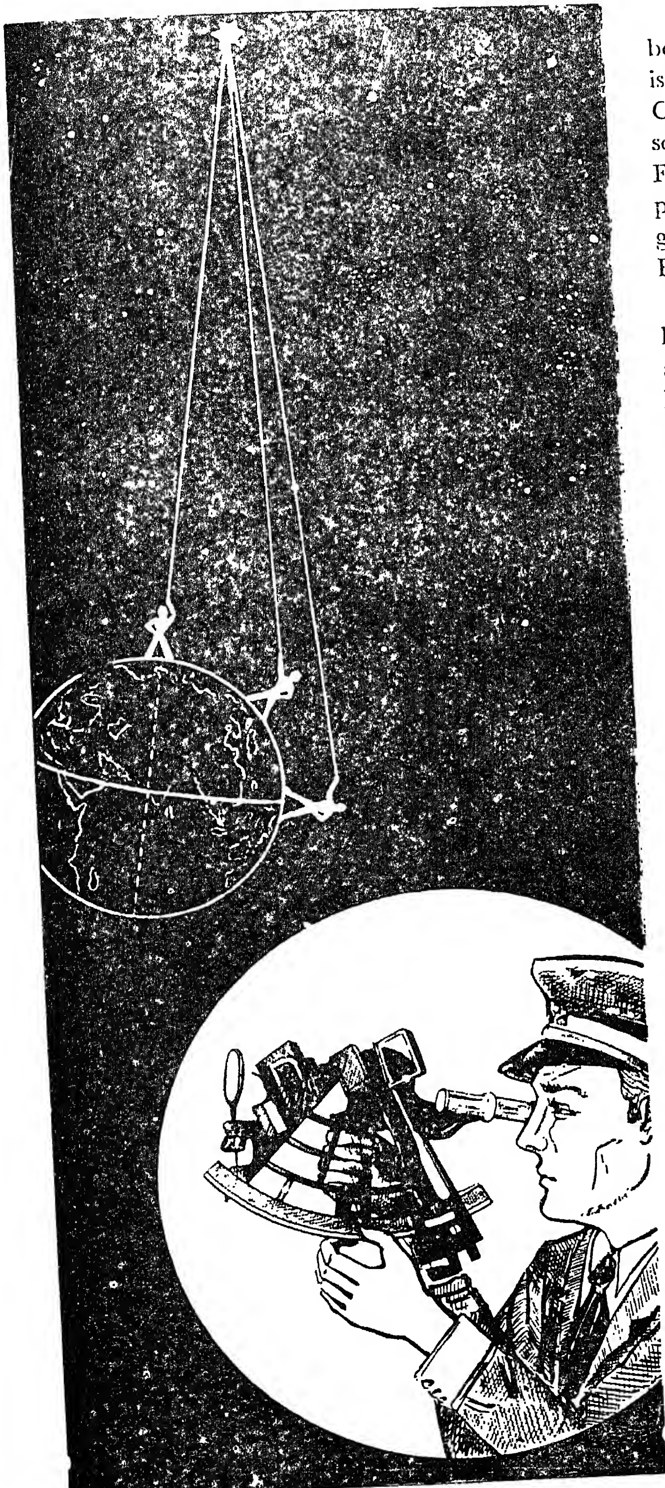


Fig. XIII.36. Navigation by the pole star using a sextant.

and try to locate yourself in space. It is by such diagrams that objects in the sky are located.

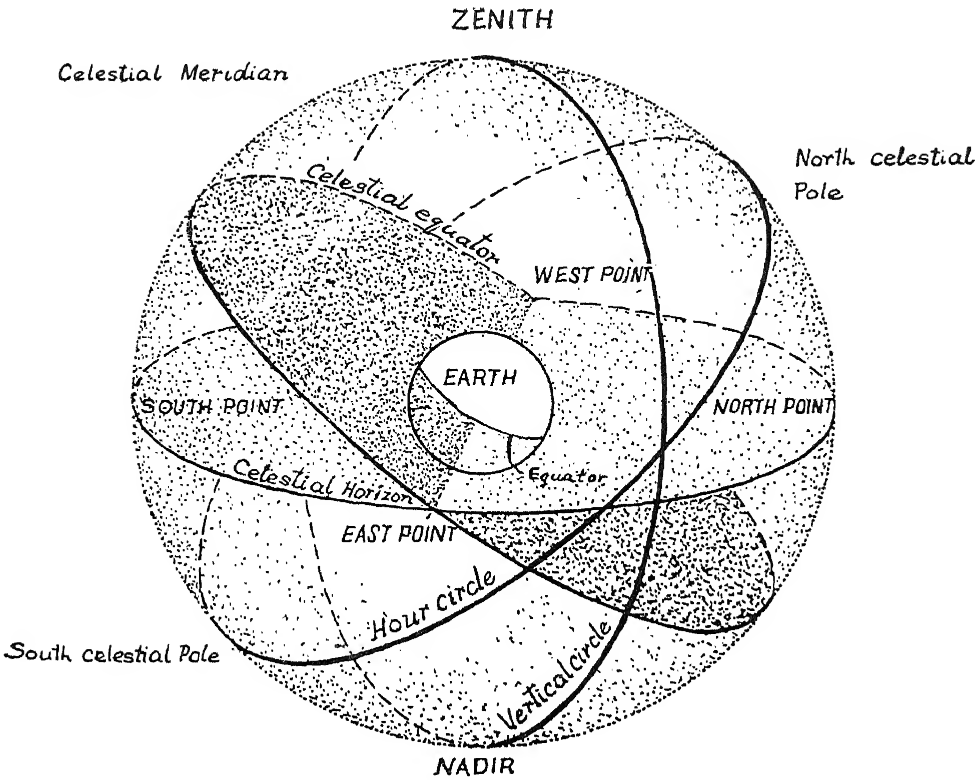


Fig. XIII.37. Mapping the celestial sphere (the sky).

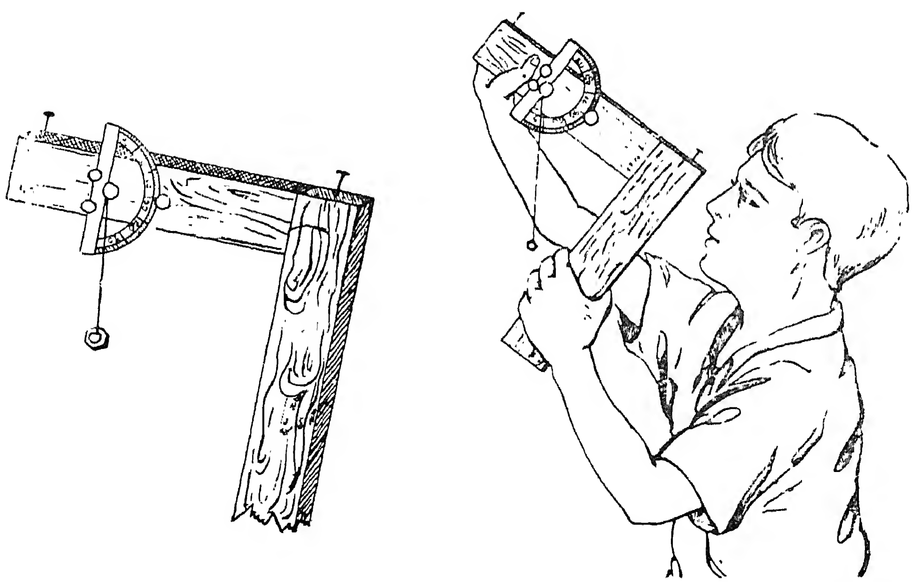


Fig. XIII.38. A latitude finder.

To find out more about locating stars, find a good astronomy book or a modern space age science book.

3. Find out about the equatorial system of star location which is used for making star maps and used with telescopes.

Concept 1-h p. 125 : A large proportion of the stars in the sky are double stars or clusters of several stars.

How good are your eyes? Test them by looking at the Big Dipper (Ursa Major) on a clear night. Focus your eyes on the bend in the handle. Do you see two stars there, one fairly bright and one dim. Some stars appear in pairs! Over a third of all known stars are double and some have three or more components. Some stars are true double stars, while others only seem to appear close together. The number of stars in the sky and the vast distances among them sometimes make it difficult to distinguish which are the true double stars. Study of double stars and the way they behave helps in relation to each other to demonstrate the way the law of gravitation holds true in the universe.

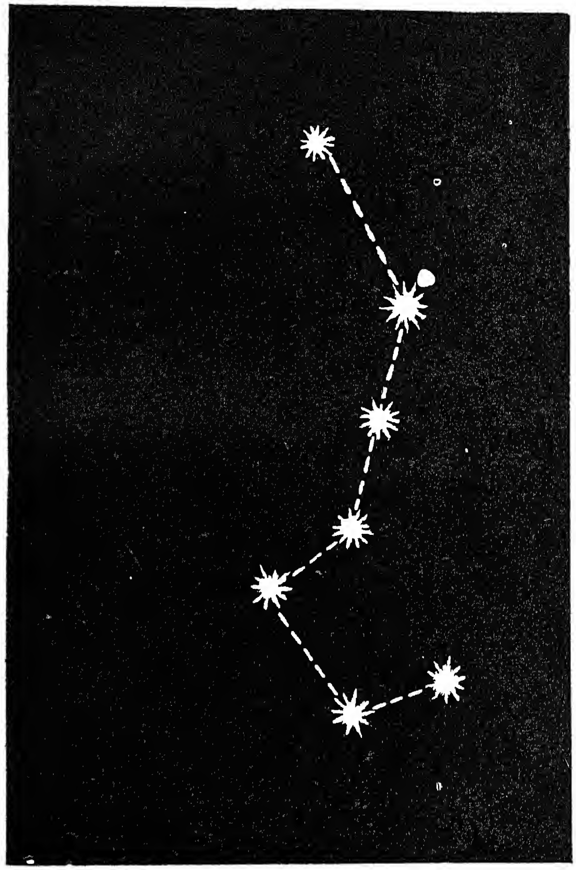


Fig. XIII.39. Ursa Major (Big Dipper) showing double star in handle.

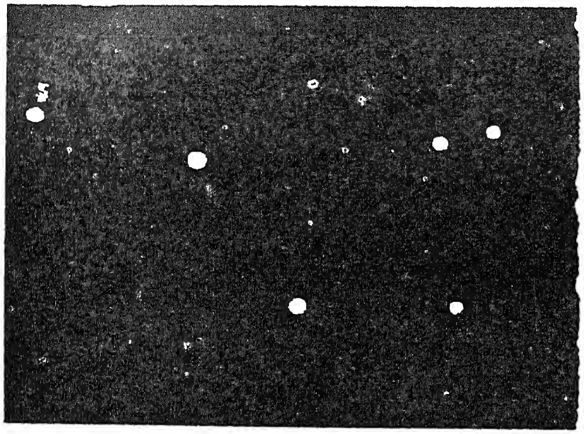
Concept 1-i (p. 125) : Millions of stars may be grouped into a cluster called a 'globular cluster' and appear as a single star, e.g., star cluster in the constellation Hercules.

1. Discuss this point : 'Every particle in the universe attracts every other particle. The effect depends on their relative masses and the distance between them.' Illustrate this with what you know about the moon, the earth, and the sun, also the planets and their relative movements. For instance, why doesn't the moon fall into the earth? What pulls more on the earth, the sun or the moon?

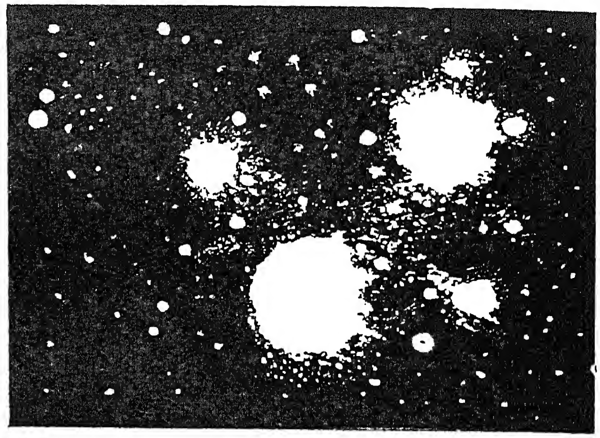
With the above in mind, discuss how star could be held together in groups of two or more or in clusters of as many as 100,000 or 1 lakh of stars.

2. Read about some of the well known *star clusters*. Find pictures of them, e.g., the open cluster of stars in constellation Perseus and the *globular cluster* in the constellation Hercules.

To study the globular cluster in Hercules, go out on a clear moonless summer night. Look for the North Star and then face South. You can see it with your unaided eyes, provided you are away from the lights of the city. Examine the



(a)



(b)

Fig. XIII. 40 a,b. Viewing the Pleiades star cluster, with the unaided eye (a), and with long exposure photograph (b).

cluster with a pair of binoculars and make a sketch of it. It will look like a glowing cloud. Also look for the cluster, Coma Berenices, near the handle of the Big Dipper (Ursa Major). In the figure given, the Pleiades cluster is seen to consist of not only six bright stars and many other faint stars, but glowing masses of dust and gas as shown in the figures.

Concept 1-j (p. 125): There are many nebulae in the sky; some are dark nebulas and appear as black holes in the sky, others are bright. The bright ones consist of scattered white-hot glowing gases.

The word 'nebula' comes from a Latin word meaning 'cloud', 'mist', or vapour that appeared like a hazy cloud. At first, star clusters and nebulae were grouped together. It took the

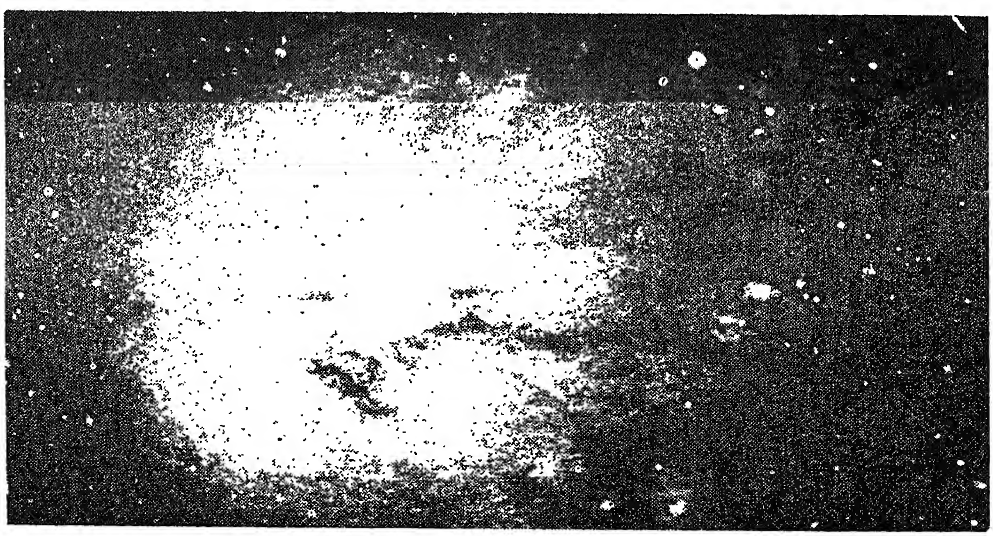


Fig. XIII.41. Trifid nebula in Sagittarius.

instrument, the spectrograph, to show the difference between star clusters and nebulae, which are not masses of stars, but masses of glowing gas which do not glow by their own light. (See Fig. XIII. 49.)

Compare a torch which gives off light, as stars do, to some smoke or steam you light up with your torch. The gas in the nebula does not have the pressure and temperature to give off light, but is lit by a hot star close by. When there is no star to illuminate the nebula, it is called 'dark nebula.'

You will hear about the famous Horse's Head Nebula in Orion. It is one of the dark nebulae of the Milky Way which is visible to us as a dark silhouette.

Major Concept 2. The stars are so far away that their distances are measured in light-years.

Concept 2-a (p. 125): A light-year is the distance that light travels in a year. Light travels 30 crore metres (186,000 miles) in a second, and nearly 60 lakhs of crores kilometres (6 trillion miles) in a year.

If someone asked you how far it is from Delhi to Bombay, would you expect to tell them it is 3,696,000 feet or about 5 crores of inches. No, you would say it is about 700 miles. How could you tell someone another way? Could you tell them in time units? Try to figure it out. Would it be 24 hours by train, 3 days by automobile, or 4 hours by turbo-prop plane and 1½ hours by jet plane?

Miles are not practical for space distances. Imagine *light-year*, which is the distance light travels in a year at 186,000 miles per second. What is your answer? It is about 6 trillion miles. Figure it in kilometers. How many crores? Would you rather speak of distances in space by the unit called light-year, or by miles?

Concept 2-b (p. 125): The nearest star to us, excluding our sun, is approximately 4.3 light-years distant.

Find out about Proxima Centauri, our nearest star neighbour. It is 4.3 light years from us. Compare this to the 93,000,000 miles to the sun (our star). How long do you think it will take light to come to us from Proxima Centauri? 4.3 years (It takes 8 minutes from our sun.)

Major Concept 3. The distances of some of the stars from the earth have been measured.

Concept 3-a (p. 125): The distances to the nearest stars have been measured by parallax, by their displacement among the distant stars when the earth is on opposite sides of its orbit. The base line for this triangulation is 186 million miles long.

1. How can we learn the distances among the stars? You recall how earlier you learned to measure by parallax the distance to the moon (see Class VII 2-f.). Two astronomers in far off observatories aim their telescopes at a particular spot on the moon. Then by determining their angle of observation and knowing the distance they are apart, they can by *triangulation* find the distance to that object.

2. Get a classmate to hold a pencil a few inches in front of you. Let your left eye be one observation point and your right eye, another. Close one eye and check the parallax, that is, the apparent shift of the pencil relative to the back-

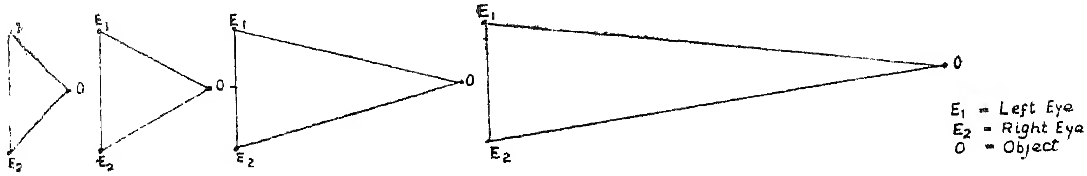


Fig. XIII.42. Using parallax to measure distances.
The more distant an object is, the less parallax there is, provided the two points of observation remain the same.

ground. Repeat this experiment with your class-mate holding the pencil across the room. The parallax is barely noticeable. You can say the angle of parallax gets smaller with distance and so measurement of far away objects will be less accurate. Recall how we tried to increase the width of our base line? How can we get a long base line for observing such far away objects as stars? (Recall, the nearest one to our solar system is 4.3 light-years away, or 2.5×10^{13} miles.)

3. How about using the earth's orbit around the sun as a base line? At one time observations can be made of a star and its apparent shift in position with respect to more distant stars and then six months later when the earth is half way around its annual trip about the sun, another observation can be made of the same star in relation to a background of remote stars. This baseline will be 186 million miles long, or, the diameter of the earth's orbit. In other words you can travel this distance and be at both points within 6 months. Here's the kind of triangle we will get if we picture our position in relation to the star. Look at Fig. XIII.43 and 44. In both we have pictured an angle of 5°.

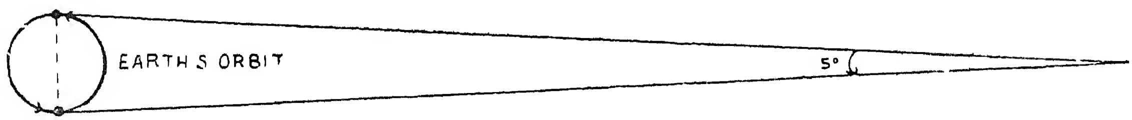


Fig.XIII.43. Using the earth's orbit as a base line for determining the distance to various stars.

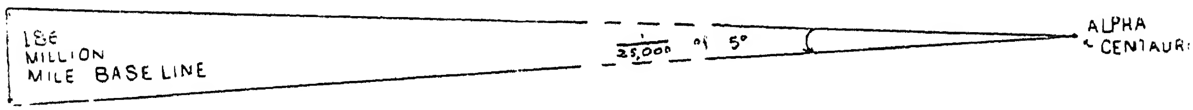


Fig. XIII.44. Angle of parallax of the nearest star to earth.

The angle of parallax of the 'nearest' star will be 1/25,000 of 5°. See what 5° is on your protractor. Then think what 1/25,000 of that angle is! We cannot picture this. Even so, astronomers can measure distances to some of the nearest stars. But distances to stars more than 100 light years away cannot be measured this way, as you will agree. Only about 1000 stars are close enough to measure in this way.

Concept 3-b (pp. 125, 126): The brightness of the nearest stars has been determined by measuring the apparent brightness at the earth's surface and then applying the inverse square law to their known distance to determine their actual brightness. Having done this, it then became possible to measure the actual brightness directly by means of a spectroscope, for it was found that stars of a given brightness produced a particular spectrum.

1. How will we measure the distance to the stars farthest away? You have observed that some stars are brighter than others. Bring a number of electric torches to school. Some with old and some with new batteries will be useful, or use a torchlight and a candle if several torches are not

available. Darken the room. Experiment by starting all lights on a line. Then move all dim lights forward toward the observers. Compare the brightness of street lights near you with those far away. Is the brightness of the stars you see each night their 'real' brightness or must you know the distance away of a star to learn its 'real' brightness?

Over two thousand years ago Ptolemy grouped the stars according to his observation of their brightnesses. He called this *magnitude*. You may think of a magnitude as meaning size, but it does not follow that biggest stars are brighter although some very large stars are very bright. What was his error? The *first magnitude* group were the fifteen brightest stars, the *second magnitude* group had in it less brilliant ones like Polaris, our North Star. The scale of magnitude has now been extended to negative. You will see, as you learn more, that the lower the magnitude the greater the brightness. What brightness do you think -4 will be? Read more about the magnitude of stars.

2. How does distance affect the light we see coming from a star? Get a 100 watt light bulb, a piece of aluminium foil about 12 in. long and 6 in. wide, and several pieces of cardboard. Wrap the foil about the light bulb so that no light escapes. Do not let the foil touch the metal base of the bulb. Screw the bulb into a socket. If you have a goose-neck reading lamp this will work well. Tear a tiny hole in the aluminium foil in the front of the bulb. Fix a cardboard as shown in the illustration. Turn on the light and mark where the circle of light falls. Now draw a square with 1 in. sides in this circle. Cut out the square.

Get a larger piece of cardboard. On this draw a square 6 in. to a side. Divide this square into one inch squares. Now you are ready to find out that the brightness of light (of a star) is related to its distance from us.

Place the cardboard with the one inch square hole against the ruled cardboard. Notice the light coming through the hole covers just 1 sq. in.

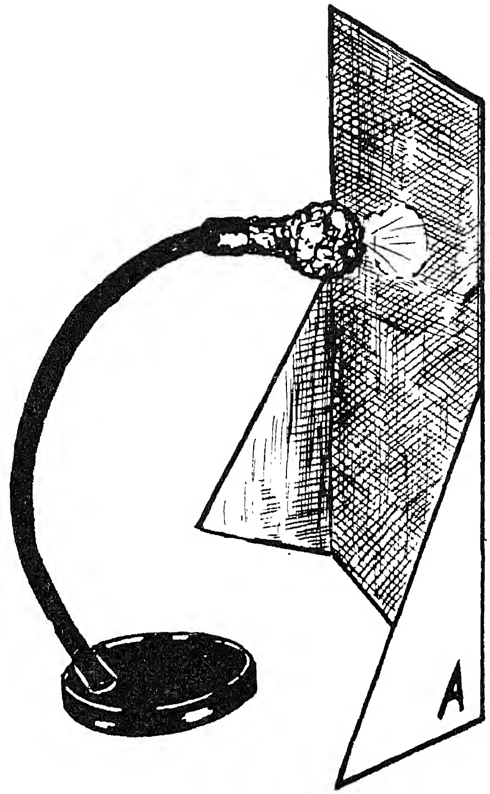


Fig. XIII.45. Demonstration of how distance affects the light seen.

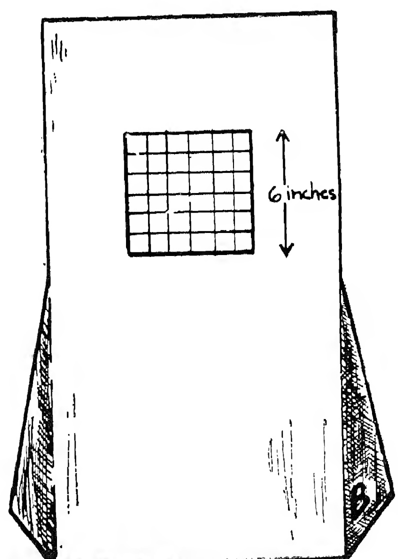


Fig. XIII.46. Cardboard with 6 in. square.

Move the ruled cardboard back 1 in. Now it is 2 in. from the light. How many squares are covered? (4) Is the light as bright? (No.)

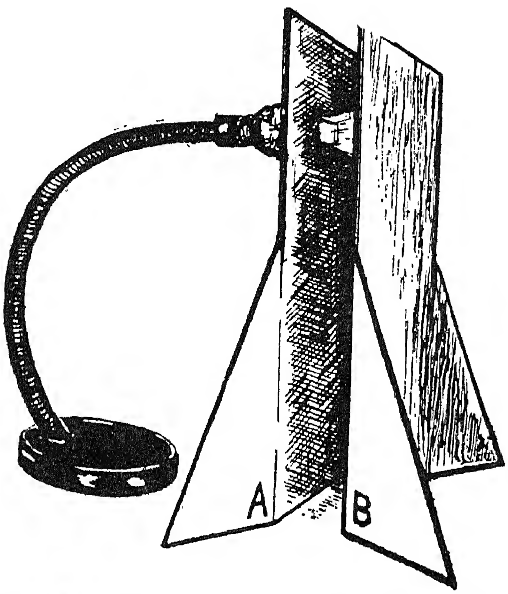


Fig. XIII.47. How does distance affect the light seen ?

Now move the ruled cardboard back another inch so that it is 3 in. from the light source. How many squares are covered? (9) Is the light as bright as when it was 2 in. away? See if you get results as those in the following Table, as you move the ruled cardboard away from the light.

Distance from light	No. of squares covered	Amount of light
1 inch	1	1
2 inches	4	¼
3 inches	9	1/9
4 inches	16	1/16
5 inches	25	1/25
6 inches	36	1/36

What relationship do you see in the two columns? We call this the *rule* or *law of inverse squares*. We say the brightness varies inversely as the square of the distance; the farther away, the less bright. All light behaves like this—star light, candle light, fluorescent light, sun light. If you have a light meter you can set up an experiment and get more accurate results.

Concept 3-c,d (p. 126): (c) It is then possible to measure the distance of more remote stars by measuring their actual brightness with a spectroscope and their apparent brightness at the earth's surface, and applying the inverse square law to determine the distance.

(d) Other indirect means have been used to measure the distances of remote galaxies but these means are all based upon the first measurements made with parallax.

Can you see that if an astronomer wished to find the distance of a star he could use this law of how distance and brightness are related.

Suppose a near and a far away star give off the same amount of light, but the star whose distance we do not know sends us 1/64 as much light according to the light meter reading. Can you use your inverse square law to determine its distance? (Eight times as far away as the first star?)

Suppose the two stars are not of same brightness. Astronomers can study the colour in a star's light by studying its spectrum. Take a prism. Adjust the prism so that sunlight passes through it and a band of colours is produced. If you do not have a prism, you may be able to make one. Take some modelling clay. Put three

microscope slides or three $2'' \times 2''$ slide cover glasses together to form a triangle (see Fig. XIII. 48).

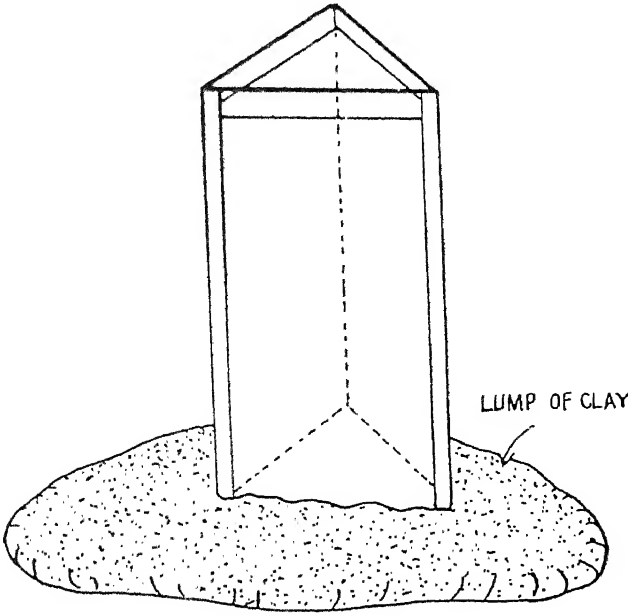


Fig. XIII.48. A home-made prism.

Imbed slides in the clay, which is waterproof. Tape the edges of the slides, pour water into the triangle until you completely fill it. Allow sunlight to pass through your prism.

See the band of colours, or spectrum. Astronomers can use a series of prisms and lenses in a device known as the *spectroscope*, which allows light from a star to pass through a slit narrower than the page of your book. As light passes through, it is broken up by a prism into a *spectrum* of many coloured lines. A camera is often used with this.

Suppose you darkened your kitchen, then placed a pinch of salt or soda on the end of a screw driver or a piece of tin and held this in a gas or spirit flame. Even the tiniest grain of salt will make an almost colourless flame take on a strong yellow glow. The yellow colour is due to the vapour of the chemical element, sodium, one of the parts of common salt. If you passed this light through a prism, unlike sunlight, only one colour of the spectrum will be seen. Any chemical that contains sodium will give off this colour whether it is in salt or in the gas of a star. In a spectroscope, sodium appears as two bright yellow lines. No other element appears like this. In a like manner you can experiment with a little cream of tartar in the flame and you get a lilac or purple colour.

Each element, when hot and glowing, produces a different and clear 'keyboard' of colours when viewed through a spectroscope. The only light emitted by each element is of the wave-length which gives the characteristic bright line spectrum of that element. Thus elements glowing as gases can be identified by the number and position of the bright lines seen in their spectrum. These bright lines serve as a 'signature' of the element.

But it is the dark lines in the spectrum, known as absorption lines, that the astronomers use in determining the presence of certain elements in the star and the temperature of the star. How do they do it? It is very simple. Any element in a gaseous state placed in front of a brighter light, absorbs light energy of the same wave-lengths that correspond to its 'bright line' spectrum. The cooler gases at the surface of a star absorb the light from the glowing interior of the star that has the wave-lengths corresponding to those of the bright line spectrum of the element. Thus by photographing the spectrum of a star and carefully measuring the position of the dark lines, (absorption lines), the astronomer can tell what gases are present in the star's atmosphere.

If he finds certain elements present as gases in the star's atmosphere, such as calcium, for example, then he knows that the temperature of the star is hot enough to vaporize calcium. By identifying the elements which are gases at the surface of a star, he determines the temperature of that star. And beyond this, any slight shift to the right or to the left in the signature of the elements present in the spectrum of a star indicates that the star may be moving toward or away from the earth.

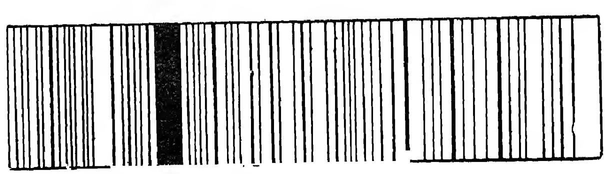


Fig. XIII.49. Representation of 'keyboard of signatures' of elements as seen through a spectroscope.

So looking at the keyboard of signature, a scientist can determine the chemical make-up of a star, its temperature, and something of its speed of movement through space. Also he learns about the 'real' or actual brightness of a star. The apparent brightness can be observed. A star with a certain 'real' brightness can have only one distance and still have the apparent brightness we observe. So in this way the spectrum of a star helps in finding the distance of that star.

Major Concept 4. Stars are arranged in galaxies and systems of galaxies.

Concept 4-a (p. 126): The galaxy in which our earth is located is an enormous flattened disc extending 30,000 light-years across one diameter and 100,000 light-years across another.

Compare our solar system's relative size and position in the Milky Way with some familiar scale such as your school, your city, your state, your country. Our solar system is not even at the centre of the Milky Way galaxy, but near an edge. A good film will help to develop this idea. Pictures from books and encyclopaedias also aid. After compiling some facts, illustrate your idea of what our galaxy looks like, then compare it with some authority. You might think of the Milky Way as a giant lens or *chappati* with spiral arms. There is a bulge at the centre. See Figs.XIII.31, 32 for a side view and a top view of it. Where would you have to be to get a picture of our whole galaxy? (Answer: out in space).

Perhaps the time it would take to reach some of these places may help us with distances. Travelling at the speed of light, 186,000 miles a second (how fast does the fastest jet travel?), we could reach the moon in a second, our sun in 8 minutes, the next nearest star in 4.3 years, but it would take 100,000 years to go from one side of our galaxy to the other and about 10,000 years to go across its greatest thickness. Our solar system is about 26,000 light-years from the centre of our galaxy.

There are about a billion stars in our galaxy. Can you think of what a billion is like? Our sun is just one of these stars and it is not even in the centre. Find our sun on the illustration. Think about yourself on earth revolving about this sun in the bigger Milky Way galaxy.

Now you belong to a family. Your family belongs to a town or city. The city is part of a state, a country. Think of an illustration to compare your life with the universe.

Concept 4-b (p. 126): Our galaxy is one of many similar galaxies,

i. Andromeda is the nearest of the great spiral nebulae. It is a member of a local group of 17 galaxies to which our galaxy belongs. Its probable distance is 2 million light-years. Its diameter is about 150,000 light-years.

Read about galaxies other than the Milky Way to find and know some galaxies in our local group, such as the great spiral in Andromeda, the Greater Magellanic cloud, the Lesser Magellanic cloud and M-33 in Triangulum. Read in recent references, as much as is being learned each year. Make a bulletin board display of how these galaxies might be viewed. Study Table XIII.4 to learn more about other galaxies.

TABLE XIII.4. INFORMATION ABOUT THE GALAXIES

Name	Constellation in which located	Estimated diameter (in light-years)	Estimated distance from earth (in light-years)
The Galaxy (Milky Way galaxy)	—	100,000	Earth is part of Milky Way
M-31 (Visible without field glasses)	Andromeda	120,000	1,500,000,000
M-33 (Visible without field glasses)	Triangulum	? (smaller than Milky Way galaxy)	1,500,000,000
Greater Magellanic Cloud (Not visible in Northern Hemisphere)	—	30,000	150,000
Lesser Magellanic Cloud (Not visible in Northern Hemisphere)	—	20,000	168,000

To help you understand your own galaxy find out about another one. On a clear night when the moon is not bright, look for the galaxy in the constellation Andromeda. If you have located the star pattern, Cassiopeia, in the circumpolar constellations (Fig. XIII. 35 b), you will be able to find Andromeda. An almanac may give you the star map for the particular season you are in. What you will see as the galaxy will be a tiny heavy cloud. Viewed up close, this galaxy will look like a great pin wheel made up of a hundred billion stars.

Concept 4-b (p. 126, 127) : ii. Hundreds of galaxies are visible with a moderate-sized telescope. They are grouped in clusters of galaxies. Within the area of Big Dipper alone, an area encompassing only 1/2000 of the whole sky, there is a cluster of more than 300 such galaxies.

iii. Astronomers estimate that about one trillion galaxies lie within the range of our largest telescopes. Approximately 17% of these are classified as elliptical, 80% as spiral and 3% as irregular.

Even this billion of stars called our Milky Way is part of a local 'city' or cluster of some seventeen other galaxies, which revolve around a common centre.

Is this group of galaxies the whole universe? Locate the Big Dipper (Ursa Major) some evening. Think now there are 300 galaxies in a cluster out in that one small portion of the sky. What is your place in the starry universe? What address would you give if you were on a trip through space town or city, state, country, hemisphere, planet, galaxy, local cluster of galaxies, universe? Can you fill all in the places?

Write the number one trillion. 10^{12} may help you keep track of your zeros. This 10^{12}, is the number of galaxies within the range of our largest telescopes such as the great 200-inch one in California, U.S.A. at Mt. Palomer.

Eighty per cent of the galaxies are either open or closed spirals. Make a three dimensional

model of an open spiral galaxy. Cut two 5-inch circles from clear heavy plastic. Hold the two circles together as you cut out areas similar to the shaded areas in the illustration. Pad the centre area with cotton until the two pieces of plastic are two inches apart. Staple the spiral arms together. Put a drop of ink at the point where our solar system is. Use a large needle to put a string through two holes. You might put some rubber cement on your model and sprinkle it with glitter to represent the billions of stars in our galaxy. Rotate the galaxy model. Take a look at our sun. Where is it? Imagine what you are looking at when you go out to view the stars at night?

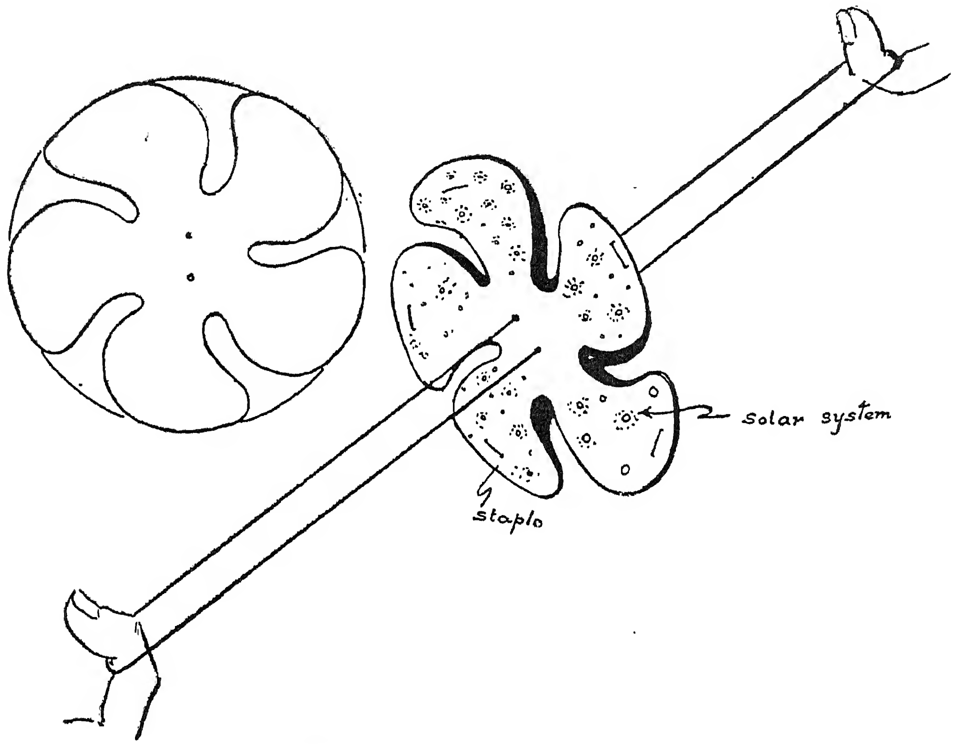


Fig. XIII.50 Model of a spiral galaxy.

Major Concept 5. Motion is everywhere in the universe. One riding on the surface of the earth simultaneously experiences these and many other motions such as—

Concept 5-a, b, c, d (p. 127):
(a) Spinning on axis at 1,000 miles per hour.
(b) Whirling around the sun at 20 miles a second.
(c) Riding through space on the rim of the Milky Way at 170 miles a second.
(d) Experiencing half a dozen other intricate motions such as whirling with the moon around a common centre about 1000 miles beneath the earth's surface, shifting as the earth's axis shifts its axis in short time and long time cycles.

Think of something that moves which is at a long distance from you. All the stars are moving, but they are so far away, you do not realise their movement.

Review and chart times for earth rotation, revolution, etc. Draw your ideas of the motions in the universe of which you are a part; the rotation of the earth about its own axis, its revolution about our star (the sun), our star's movement near the rim of the Milky Way in its local group of galaxies and finally the movement of the whole universe.

Here are some questions you may wish to read about to find the answers:

1. Is there evidence that the universe is constantly changing?

2. What proof do astronomers have that the universe is expanding?

3. How can astronomers discover that galaxies are receding from each other?

4. What evidence leads astronomers to believe that the stars are several billion years old?

Major Concept 6. There are many hypotheses to account for the origin of the earth.

Concept 6-a,b,c,d,e,f,g (p. 127,128):

(a) According to Chamberlain and Moulton, the near collision of a passing star pulled away some materials from the sun to form the planets.

(b) According to Jeans and Jefferies, a star passing close to the sun caused tidal eruptions that sent materials in streaming arms from the sun and set this material revolving like a pin-wheel. This material formed the planets.

(c) According to Hoyle, the planets and satellites were formed from the fragments of a companion star of the sun which exploded with tremendous force into space.

(d) If the earth were formed by a unique occurrence or an accident (as in a, b, or c) the chances of there being other solar systems like ours are very few, for the distances between the stars are so vast.

(e) According to Kant and LaPlace, the solar system and the earth arose from a mass of hot swirling gases which condensed to form the sun and the planets.

(f) According to Von-Weizsacker, the present solar system was originally a disc of whirling gases from which a system of cells was created. The central cell became the sun and the others whirling around condensed to become the planets.

(g) If the earth were formed as above (e, and f), astronomers conjecture that there might be a million planets with conditions suitable for life as we know it on earth, out of a possible billion stars in our galaxy with planets revolving around them.

Discuss the various theories of the origin of the earth and our solar system. (Refer to concepts and sub-concepts).

Get an astronomer to come to your class and help you understand these theories. Read about these theories in authoritative books of recent publication. Why are a number of theories disbelieved today?

If possible show a film which presents material on the origin of the earth.

Write a paper on, 'Why I do or do not believe there are other solar systems like ours.'

Major Concept 7. The earth is very old. Its age has been estimated in various ways.

Concept 7-a (p. 128): There are many reasons for believing that the earth is very old, such as—

i. The rocks show many evidences of change—fossils formed at the bottom of the sea are now found high in some mountains.

ii. Metamorphic rocks, such as mica and schist are found high in many mountains. These schists were formed from clays deposited in shallow seas. Great heat and pressure were required for the formation of the schists. So mountains of sediments must have been laid down on top of the clays and these must have been worn away. Later the schists must have been raised into mountains. Much time is required for this.

1. It is not difficult to believe that the earth is old, but *how old* is a question. The earth itself has to tell this story. Fossils are considered to be preserved evidence of ancient life.

The fact that fossil remains of sea animals have been found far inland and also on the top of mountains gives clues to the changes that have occurred over long periods of time. Many people contribute to the piecing together of the earth's history. Fossils have been collected by the hundreds of thousands by scholars of every nationality. How does the scientist work at this problem? He seeks fossils in the rocks, sands and clays throughout all the lands and waters of the earth. The best places to find fossils are in sedimentary rocks. Why is this true? The scientist takes these fossils to his laboratory for study, compares them with others; identifies them, determines their ages, and finally describes them in terms of Earth's history. Sometimes there are big gaps in the records; sometimes the scientists do not have enough evidence to form a theory.

Do rocks in your region have fossil deposits? Arrange a field trip to study fossils either in the field or at a museum. Sometimes farmers come upon these fossils when cultivating their land, or engineers when drilling for oil. It is important to have many specimens. Take them to men who study fossils in terms of the earth's age.

If possible obtain a fossil collection for study. Find out what geologists or palaeontologists believe about the age of rocks in your region. If someone you know collects fossils, have him tell you about his work and its meaning.

Do you have a division of geology in your State Government? Find out if it has any material directly related to the place where you live.

Collect pictures of pre-historic plants and animals.

Study a geologic time table (refer to the chart, 'Living Things', Unit VIII, Concept 8-c). If you were to look for fossils in precambrian rocks, what kind would you most likely find?

2. We know that when sediments are laid down in water, they are nearly flat. Observe a stream or river where sediments are being laid down. Imagine that some day these sediments may be part of mountains.

Try this in your classroom: Dig a shallow hole in a pan or box of sand. Drop a bone, shell, or other object into the hole. Direct a fine stream of water over the sand that surrounds the hole. Observe how the object becomes covered as sand is washed over it.

Visit a pit, a road cut, or excavation; perhaps one being dug for a building foundation. Observe

the different kinds of rock or soil at different levels. It is partly by means of different rock layers found on top of one another that scientists have learned about Earth's history.

Discuss the finding of rocks, like mica schist, on top of mountains, that were formed originally from clay sediments laid down in water.

Find pictures of rocks that have been folded, tilted, broken and greatly changed. Observe that changes such as these do not occur in your daily life; therefore it must have taken a long time.

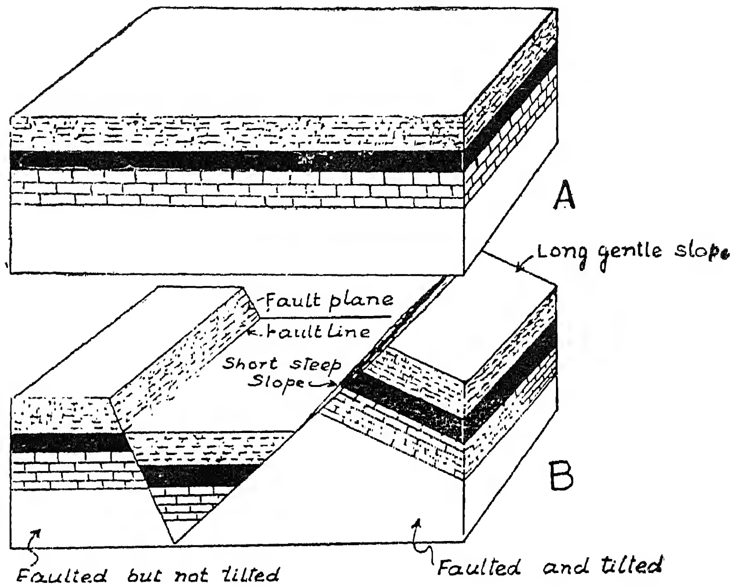


Fig. XIII.51. Faulting of bed rock.

Concept 7-a (p. 129):

iii. There is great diversity among the various living things found on the earth. These are believed by many to have evolved from a single form. This would require much time.

iv. These changes that have taken place can be used to estimate the age of the earth.

There has been constant change, or *evolution*, of living things since the origin of life. The animals and plants of any one age differ from those that came before and those that came after.

Rocks 45 million years old contain fossil remains of four-toed horses, crocodiles, *Magnolia* and maple trees and monkey-like primates. Rocks half a million years old contain modern-type horses, cave men, alligators, maple and *Magnolia* trees. Read more about the history of living things and design your own chart of your findings.

It is believed that more primitive organisms of both plants and animals are found in older rocks, and more complex organisms in younger rocks.

The oldest known plant, a seaweed (alga) 1700 million years old, and the oldest known animal, a jelly fish, 1200 million years old, are complex enough organisms to lead scientists to believe that life must have been evolving for millions of years in order to produce them.

Find out about the four-and three-toed horses. Read about the tree fern as an ancient plant. Why do we not find fossil 3-toed horses in the same beds as fossil 4-toed horses?

Discuss the belief of many scientists today that life originated only once and has been continuous

ever since; that in all forms of reproduction the actual living material of the parent cell becomes the living material of the daughter cell. Excepting one-celled organisms other cells change to produce the rest of the new organism. This means that ultimately every living creature is directly related to every other creature, living and dead.

Concept 7-b (**p. 129**)**:** The age of the earth has been estimated from the total depth of the deposits found on the earth. In an out-crop of sediments, the youngest sediments are on top, the oldest are beneath.

i. The comparative age of deposits found in one location have been determined by such methods as the sequence of strata, the kinds of fossils found (index fossils), and in other ways.

ii. By co-ordinating deposits over the earth's surface, geologists have developed a geological column 100 miles in depth. By estimating the average rate at which deposits are made, and then calculating how long it would take to form a layer of sediments a mile deep, an estimate of the age of the earth has been made.

Discuss this statement:

'We expect to find that younger sedimentary rocks are deposited on top of older ones, unless movements in the earth's crust have disturbed this.'

Find out how scientists 'read the rocks'.

(i) Demonstrate this by placing a handful of pea-size gravel in a beaker or wide-mouthed jar. Sprinkle a handful of sand on top of the gravel. Next add more gravel, and observe the layering. Which material was deposited first and is therefore older? Is it possible to introduce another layer without disturbing the sequence of layers? (What movements in the earth's crust could disturb the sequence?) Geologists can study layers in one out-crop of rock and compare this out-crop with that in another area. If they find

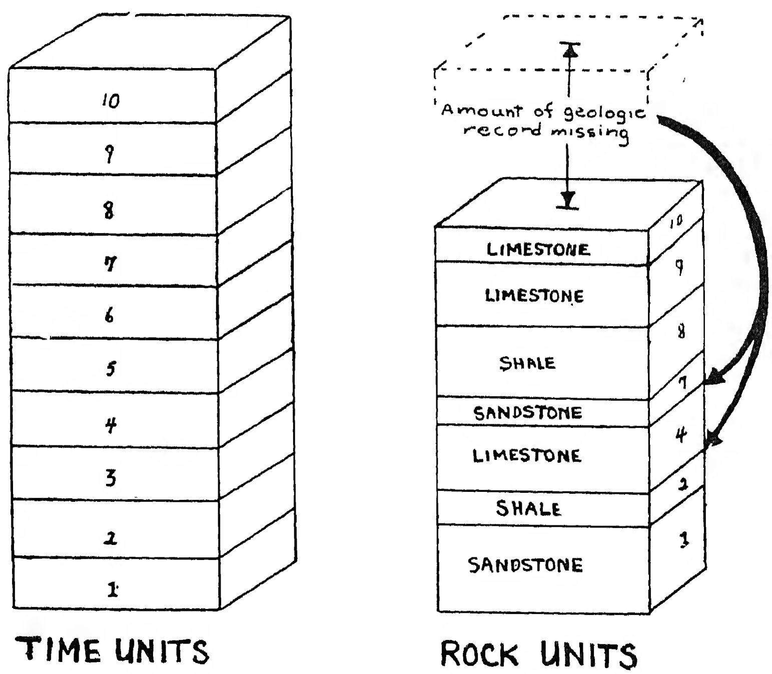


Fig. XIII.52. Time-rock relationships.

guide or index fossils, these can be used to date the various strata or layers in geologic time.

Study the accompanying time-rock chart and see why the rock sequences are sometimes incomplete, often due to erosion (Fig. XIII.52).

Some fossils are typical of a particular period in earth's history. These are called 'index' fossils. An index fossil defines a very limited time range. A three-toed horse is an index fossil, as is the trilobite. Find out through your reading about some other index fossils. Make a chart of these with dates and report to your class.

How could an index fossil aid an oil or coal geologist?

Can you think of any animal or plant today that would make a good index fossil? Think of those that are nearly extinct which have also been relatively short lived.

(ii) How fast are sediments laid down? Watch a stream bed or mud puddle as sediment is laid down. Estimate how long it will take for a mile high column to be laid down. Scientists have found it takes 4000 to 10,000 years for a layer of sedimentary rock one foot thick to be formed. Here is a problem for you. Suppose that during one geologic period 6000 feet of rock was deposited. One foot of rock is deposited in 5000 years. How long was the depositing going on during this particular period? (Is your answer 30,000,000 years?) Of course the amount of erosion going on varies.

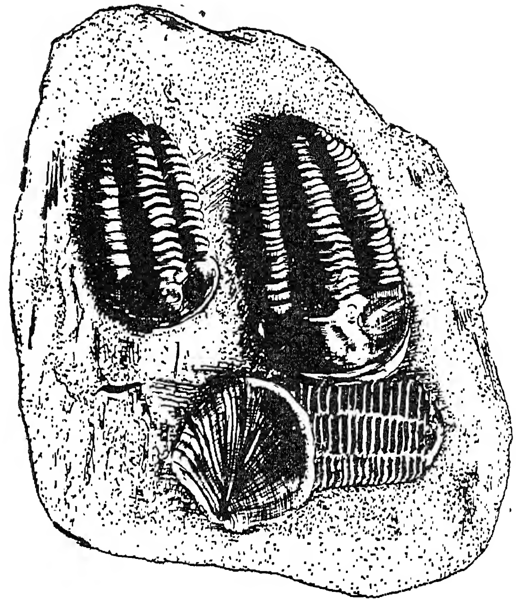


Fig. XIII.53. Fossil Trilobites.

Concept 7-c (p. 129, 130): The age of the earth has also been estimated by other means:

i. By assuming that to begin with the oceans contained fresh water, and that the salt has been carried into the ocean, an estimate of the age of the earth can be made. Measurements of the percentage of salt in the ocean, the volume of the ocean and the salt carried into the ocean each year by the rivers have been made. This method shows the earth to be very old.

ii. A dependable measure of the age of certain rocks has been made by the ratio of uranium to the particular form of lead formed by the disintegration of uranium. 1/637th of uranium disintegrates to form lead in one crore of years; during the next crore another 1/637th of the uranium disintegrates, and so on. Samples of the oldest rocks tested in this way have shown the age of these rocks to be approximately 200 crores of years old. The age of the earth must be at least 200 crores of years; it is quite certain that the earth is much older than that.

(i) What disadvantages do you see to the method of determining the age of the earth by estimating the salt in the ocean?

A portion of the sea may be cut off by the rock movements, returning the salt to the land that was once in the sea.

(ii) Scientists have ways of measuring the age of rocks Some of these are by radioactive 'clocks'. Some rocks contain elements that are radioactive These rocks give off radiation As this occurs, the original elements disintegrate or change into lighter elements With uranium this goes on until lead is formed. The rate of change is constant, but very very slow

Find out about radioactive uranium and how it changes or disintegrates slowly into lead To show how slowly this occurs take a pea. Cut it in half, and then into fourths. Think of this the fraction of each gramme of uranium that changes to lead each year is not $\frac{1}{2}$ or $\frac{1}{4}$, but $\frac{1}{7,600,000,000}$.

The formula for figuring this change is

T (time passed, or age of the radioactive material)

$$= \frac{\text{Weight of lead (Pb)} \times 7,600,000,000}{\text{Weight of uranium}}$$

Pitchblende, one kind of uranium in igneous rocks, was found to contain (0 1) 1/10 gramme of lead and 0 33 of a gramme of uranium. Substitute the numbers in the formula and see what you get for the age of the earth.

$$T = \frac{0\ 01 \times 7,600,000,000}{0\ 33}$$

Did your answer come out to about 2,300,000,000 years? (230 crores).

To help project the great age of the earth, calculate the number of seconds in a year, which rounded off is 3 crores If you count one number every second, day and night for a whole year, you could count 3 crores It would take 10 years to count 30 crores, 60 years to count 180 crores 63 years to count 210 crores (2,000 million years) and 65 years to count 230 crores No doubt the earth is much older than this, because this gives only the age since uranium was formed

Find out about other methods of determining the earth's age, as rubidium-strontium decay and potassium-organ decay

Major Concept 8. To travel in outer space we must first place a vehicle in orbit.

Concept 8-a (p. 130): Outer space begins where the earth's atmosphere ends.

If you do not have a chart of the earth's atmosphere and outer space, refer to recent books and make one. In this way you can keep track of record flights of air craft and the new satellites that are put into orbit Review the composition and characteristics of air. Compare the earth's atmosphere with outer space (see Fig. I.7).

Where does outer space, sometimes called the *exosphere*, begin? It is not known for sure, but many feel that 600 miles above the earth puts us at the edge of outer space Where is the top of outer space? Here in the exosphere it is dark and there are practically no gases. What else can you find out about outer space?

Make a graph showing temperatures at different altitudes.

Explain what problems must be solved to enable men to journey safely through space.

Find out how much of space has been explored and how.

Concept 8-b (p. 130): Rockets are used to put a vehicle in orbit.

1. Read about the history of rockets. How was gunpowder used in a rocket arrow. What was Fontana's rocket car? Find out that more than 400 years ago the Chinese tried fire crackers on their first 'spaceship'. Of course, youk now it never got off the ground, but they were operating on a sound physical principle. What was this principle? In 1814 the British used a rocket gun in their attack on Washington, D.C. You will want to learn about Dr. Robert Goddard's experiments, Dr. Werner von Braun's and others. Check on Sir Isaac Newton's third law of motion. Why does a rocket fly?

A rocket is an engine that is not dependent on the oxygen in the earth's atmosphere to combine with its fuel.

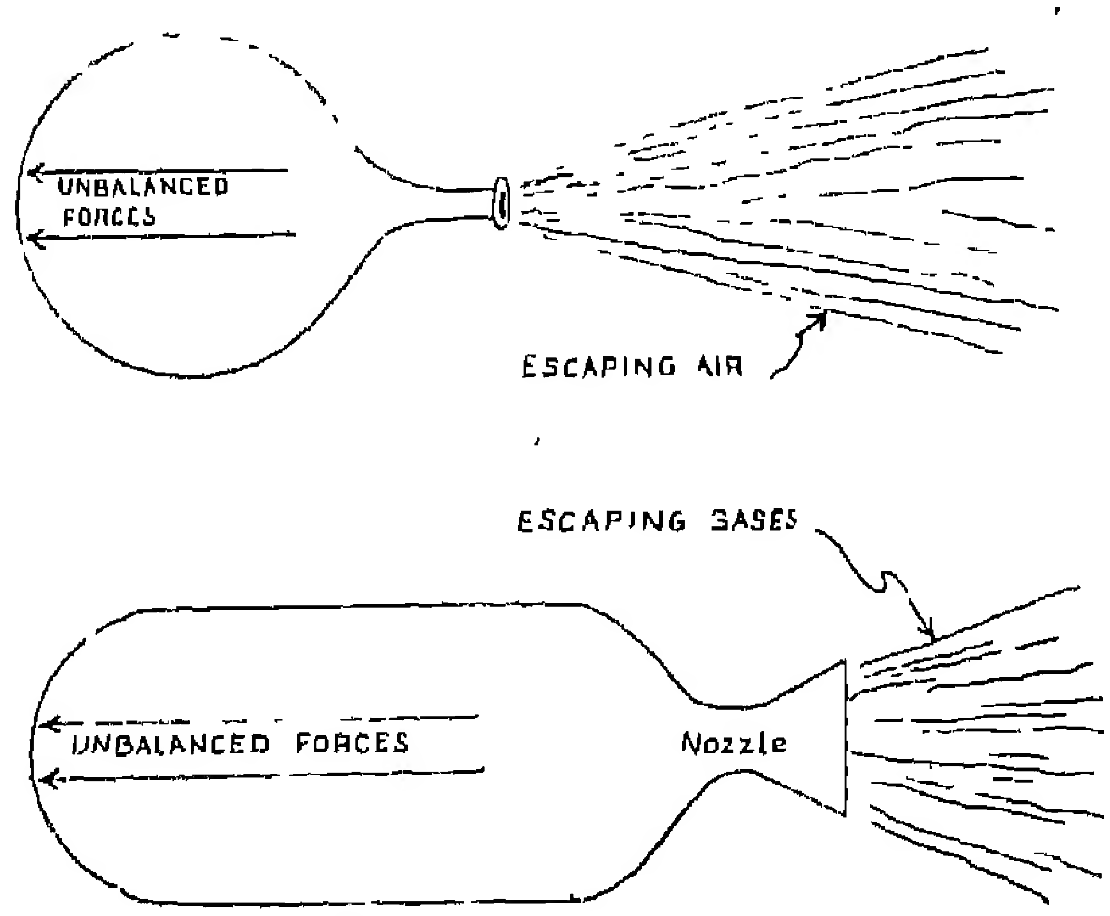


Fig. XIII.54. Rocket propulsion.

2. Explain the motion of an inflated balloon when you release the nozzle. In both the rocket and the balloon escaping gases produce unbalanced forces at the point opposite the opening. This push, or propelling force, is within the balloon and within the rocket

3. Use a pencil to make a $\frac{1}{2}$ inch hole in one end of a light-weight cardboard box. Insert the nozzle or neck of a balloon through this hole, with the mouth outside the box Blow up the balloon and hold its neck closed Then place the box on a half dozen soda straws for rollers and release the balloon. What happens? Explain this in terms of 'every action is accompanied by an equal and opposite reaction'.

4. Lay a small flat bottle on two round pencils so that it can roll freely Pour some vinegar in the bottle and do not let it run out. Take a teaspoonful of bicarbonate of soda (baking soda) and wrap it in a piece of tissue paper Place this in the bottle. Cork the bottle loosely, but air-tight. What happens?

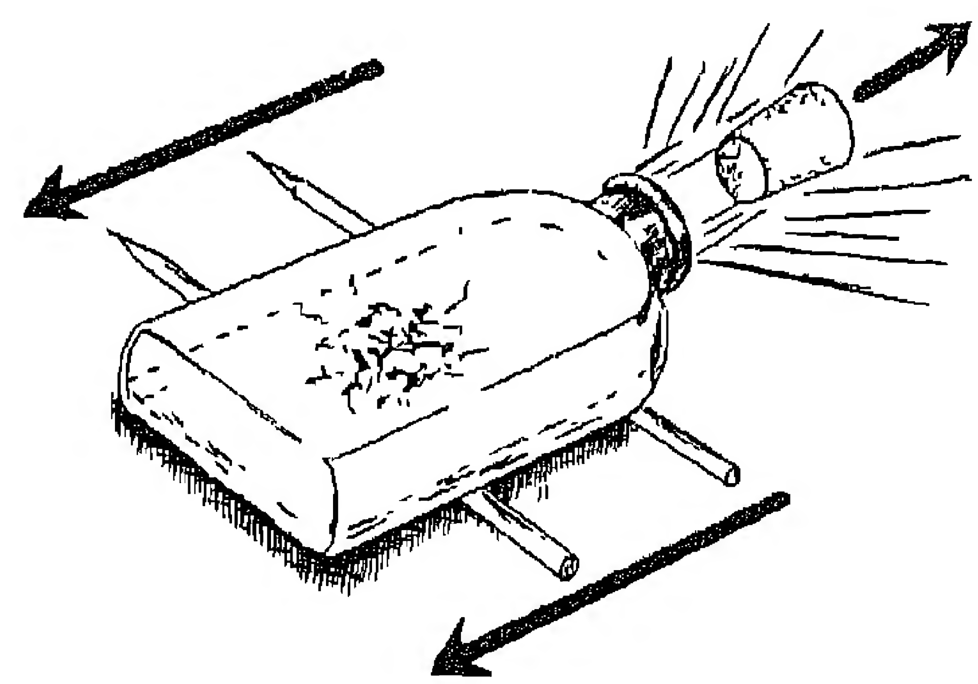


Fig. XIII.55. Rocket propulsion in a bottle.

The baking soda reacts with vinegar and produces carbon dioxide (CO_2) gas As the gas expands in the bottle it causes the cork to fly out. Which way does the cork go? Which way does the bottle go? Pretend the bottle is a rocket. Explain what happens in terms of Newton's third law.

Concept 8-c (p. 130): Much thrust is needed to move the rockets away from the earth.

What do we mean by *thrust*? How is a rocket's thrust created? Inflate a balloon and release it. What caused it to move? Attach a short loop of string to the balloon and hang a

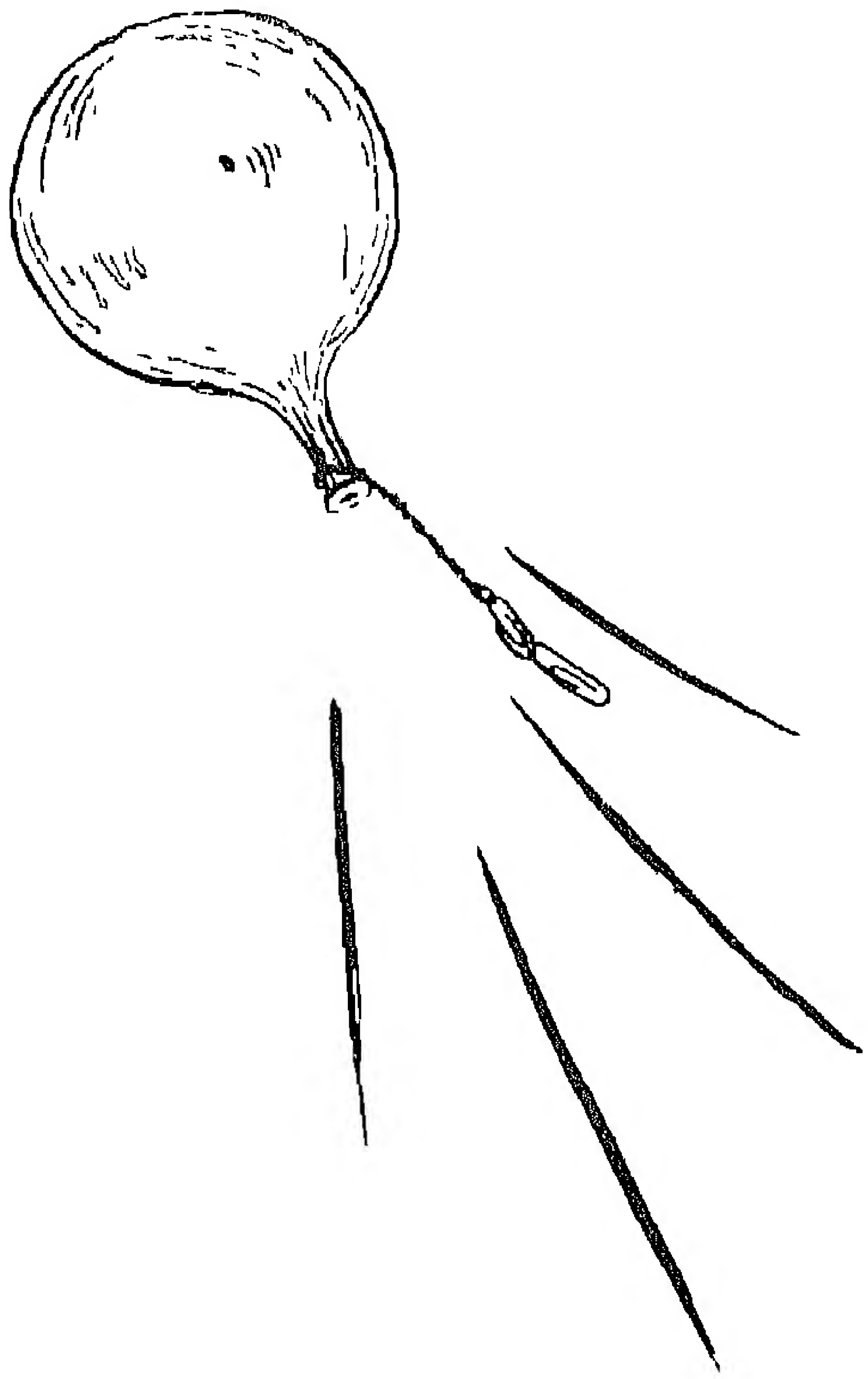


Fig. XIII.56. What law is demonstrated?

paper clip on it. Inflate the balloon and see if it will lift the paper clip. Keep adding paper clips until the balloon will not lift them

The number of clips your 'rocket' balloon lifted is a measure of the thrust. This determines the load a rocket can carry. A rocket's thrust must be strong enough to escape the pull of gravity toward the earth to go into orbit around the earth

Explain how the third law of Newton 'for every force there is an equal and opposite force', works in rockets Some people think that a rocket moves forward because the escaping hot gases push against the air behind it. If this were so the rocket could not operate out of earth's atmosphere. Why? The expansion of gases within the rocket produces an opposing pair of forces As gases push against the rocket, the

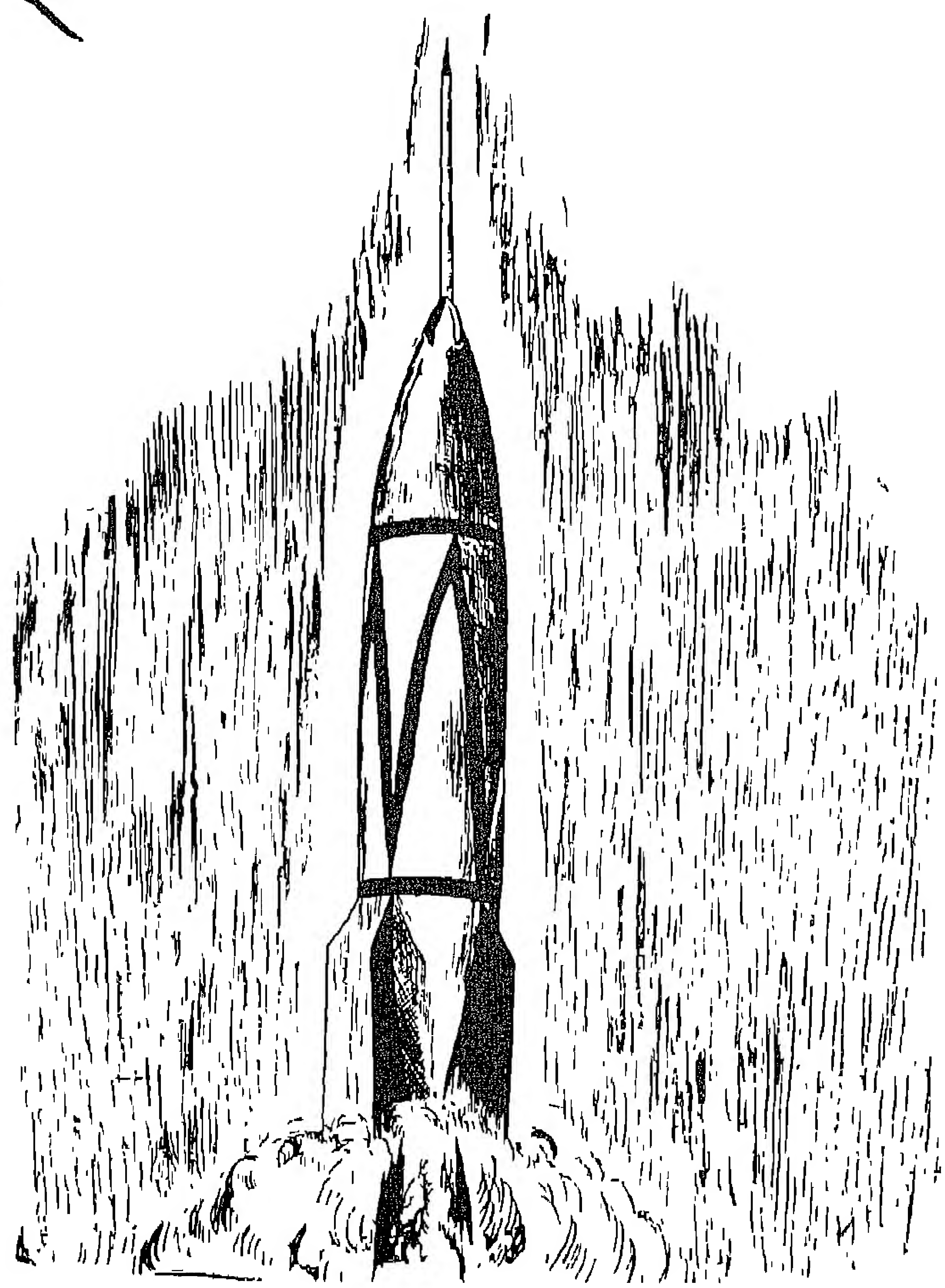


Fig. XIII.57. Powerful rockets are needed for space probes.

rocket pushes back. Thus the gases are pushed back by the rocket and the rocket is pushed forward by the gases

Find out about rocket fuels What are the advantages and disadvantages of liquid fuels? Of solid fuels? [Refer also to Unit VI, Class VIII, II (5-9)] Can nuclear energy be used?

To obtain the greatest thrust the gases of rockets should be hot, light, and be expelled rapidly —have a high exhaust velocity. Rockets can now be built with thrust in the order of 400,000 lb In order to propel space vehicles to the moon 1,000,000 lb. (10 lakhs) and more of thrust is necessary.

Make a match-head reaction engine. Wrap the head of a paper match in a small piece of aluminium foil. Hold a pin next to the match while wrapping the foil about it. When you withdraw the pin it will leave a small nozzle for the exhaust gases. Be sure to fold the foil over the head end of the match, so the gases will not escape toward the front Place the wrapped match inside a piece of glass tubing. Let the head protrude. Hold the wrapped match head over a candle until it ignites. With practice the match can be propelled at least 10 feet.

Concept 8-d,e (p. 130, 131): (d) To place an object in orbit, it must be raised several hundred miles, and then made to move fast parallel to the surface of the earth It must go fast enough that even though it is freely falling toward the earth, it never reaches the earth—for the earth curves away from it.

(e) When a space vehicle is in orbit, the gravitational force of the earth on the vehicle and its occupants is balanced by the centrifugal force of the vehicle travelling rapidly parallel to the earth's surface. The occupants of the vehicle will experience weightlessness.

Think about our own satellite, the moon, for a while. Why does it not fall into the earth? We know every bit of matter pulls on every other bit of matter in the universe and the bigger the mass, the more the pull (see Fig. XIII.3).

The spool or stopper doesn't fall nor does it fly away. Why? There are two forces at work. Something like a giant string, which represents the force of gravity, holds the 'moon' from flying away. Gravity does not pull the 'moon' down

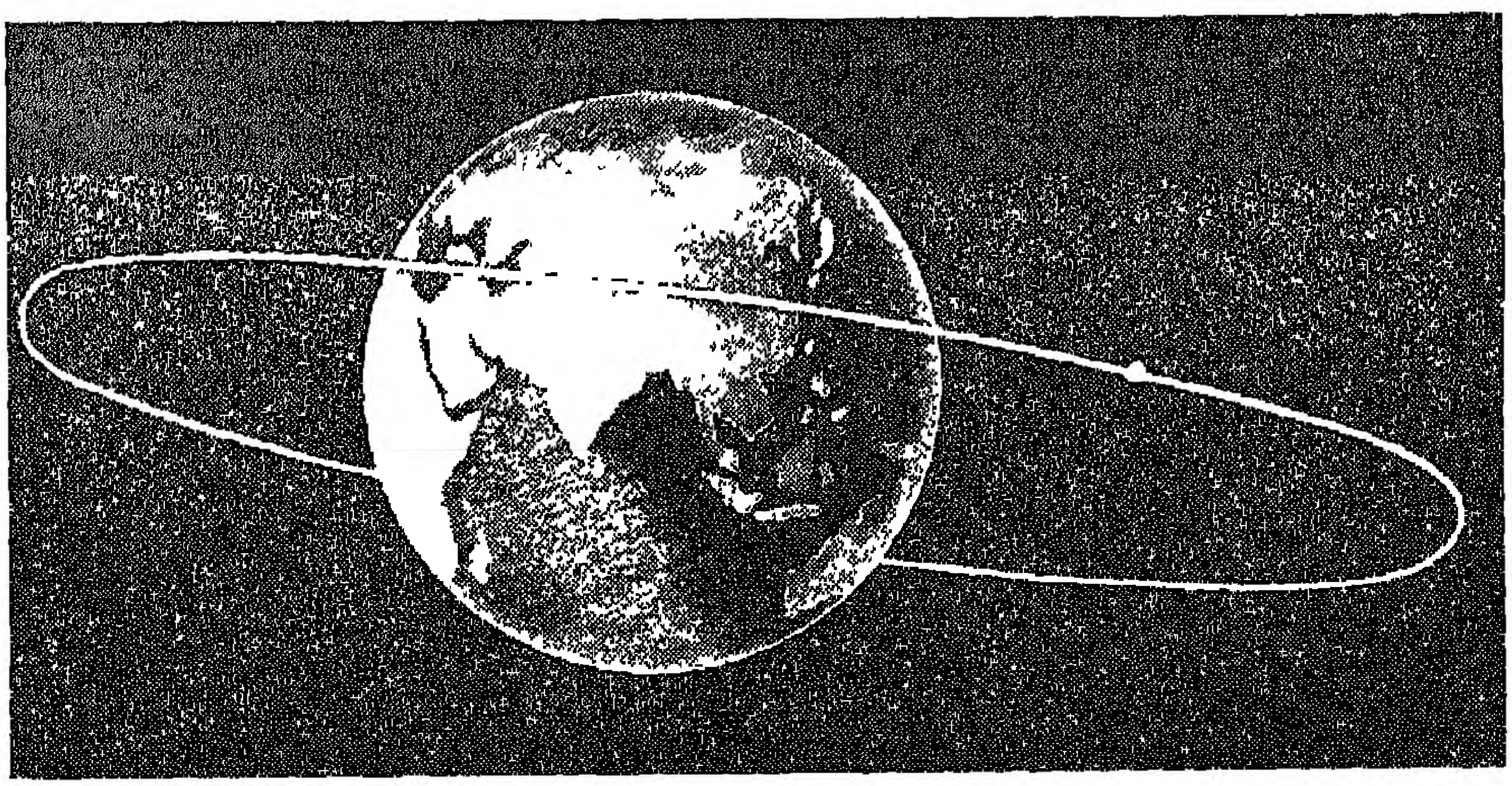


Fig. XIII. 58. Satellite in orbit around the earth.

because the moon is moving fast in a horizontal direction. Because there is a balance between the pull of gravity toward earth and the tendency of the moon to keep moving forward, we find the moon falls towards the earth; in fact, 'around' the earth because earth is curved, but never falls into the earth. We say the moon is in *orbit* around the earth.

Try this. Place two blown-up balls on a table Let one drop gently from the edge Gravity pulls it to the floor Push the other ball off with considerable force. It will fall in a curved path because its inertia tends to carry it forward in a straight line as gravity gradually overcomes the inertia and pulls it down. (See Fig. VI. 98.)

Fig. XIII. 59. Weightless condition.

Imagine turning off gravitation for 24 hours What effect would this have on orbiting objects ?

When a space ship is beyond the earth's gravitational pull or when earth's pull is balanced by the motion of inertia, then weightlessness is experienced.

Practice getting the feeling of weightlessness. As the parts of your body press against each other you feel body weight. Once this pressure is removed, you feel weightlessness. How do you feel when you jump, before you land? Have you ever taken a high dive into a swimming pool?

Have you ridden in an elevator when it suddenly drops? Or ridden in a roller coaster?

Every baseball you throw is weightless during its flight.

A parachutist experiences weightlessness if he free falls before opening his chute. An airplane can execute a steep climb and then glide through an unpowered arc, and in this way effect weightlessness. Space is distorted during this time. There is no up or down. What is up, anyway?

Find out the problems of being weightless, for example in sleeping, in drinking, using tools, moving heavy objects, and any actions dependent on gravity Give your suggestions for solving some of these difficulties in space-ships

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Concept 8-f (p. 131): To re-enter the earth's atmosphere and return to earth, the vast energy expended as the vehicle was thrust into space must be dissipated as heat.

i. Highly refractory materials are used in the capsule
ii The shape of the capsule is designed so dissipate much of the heat in a shock wave.
iii. Experiments with high altitude flights are being conducted to build a space ship that can fly back to earth much like a conventional aeroplane

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Some satellites have stayed in orbit only a short time. For instance, Sputnik I stayed up only 3 months; then it fell to the earth and burned up Explain what effect distance from the earth will have on the orbit of a satellite.

What happens when the space ship returns and re-enters the earth's atmosphere?

Rub your hands together slowly and then rub them very fast Describe what you feel. Perhaps, you have seen someone start a fire by rubbing two pieces of wood together. This is the heat of *friction*. A space ship travelling at thousands of miles an hour descends towards the earth In the earth's atmosphere are countless atoms of air to rub against. This friction with the atmosphere of the earth slows the ship down, but the energy which the ship loses is changed into heat. The motion of the ship produces rapid motion of the air particles. This heats the atmosphere. The hot atmosphere heats the ship so hot that some surfaces burn.

1. Find out about kinds of materials, called refractory, that will withstand very high temperatures. For example, Project Mercury has a special surface, some of which burns away. In this way much heat is dissipated and the metal beneath is protected

Bake a potato after wrapping it in aluminium foil. Show how the aluminium acts as an insulator in the coals of the fire.

In this chart *mach* numbers on the base line stand for multiples of the speed of sound, using mach 1=750 mile per hour near the earth's surface.

If a capsule can be slowed down there will be less heat created

2. Nose cones or the front end of capsules are designed to avoid excessive heating. See the shapes in Fig XIII 61. The blunt nose causes much of the hot atmosphere to flow past it without heating the space ship. Study the

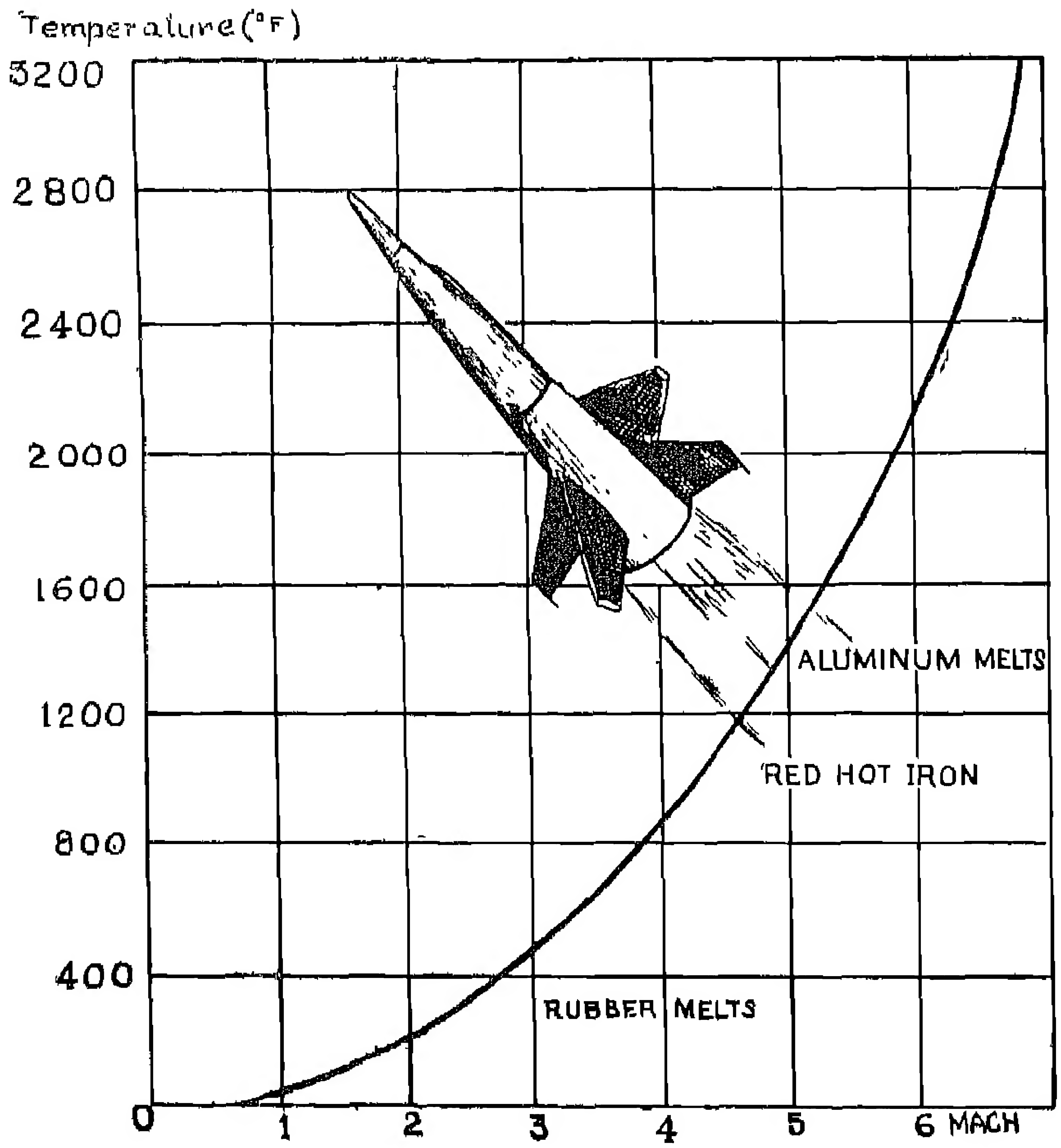

Fig. XIII 60. Heat of re-entry.

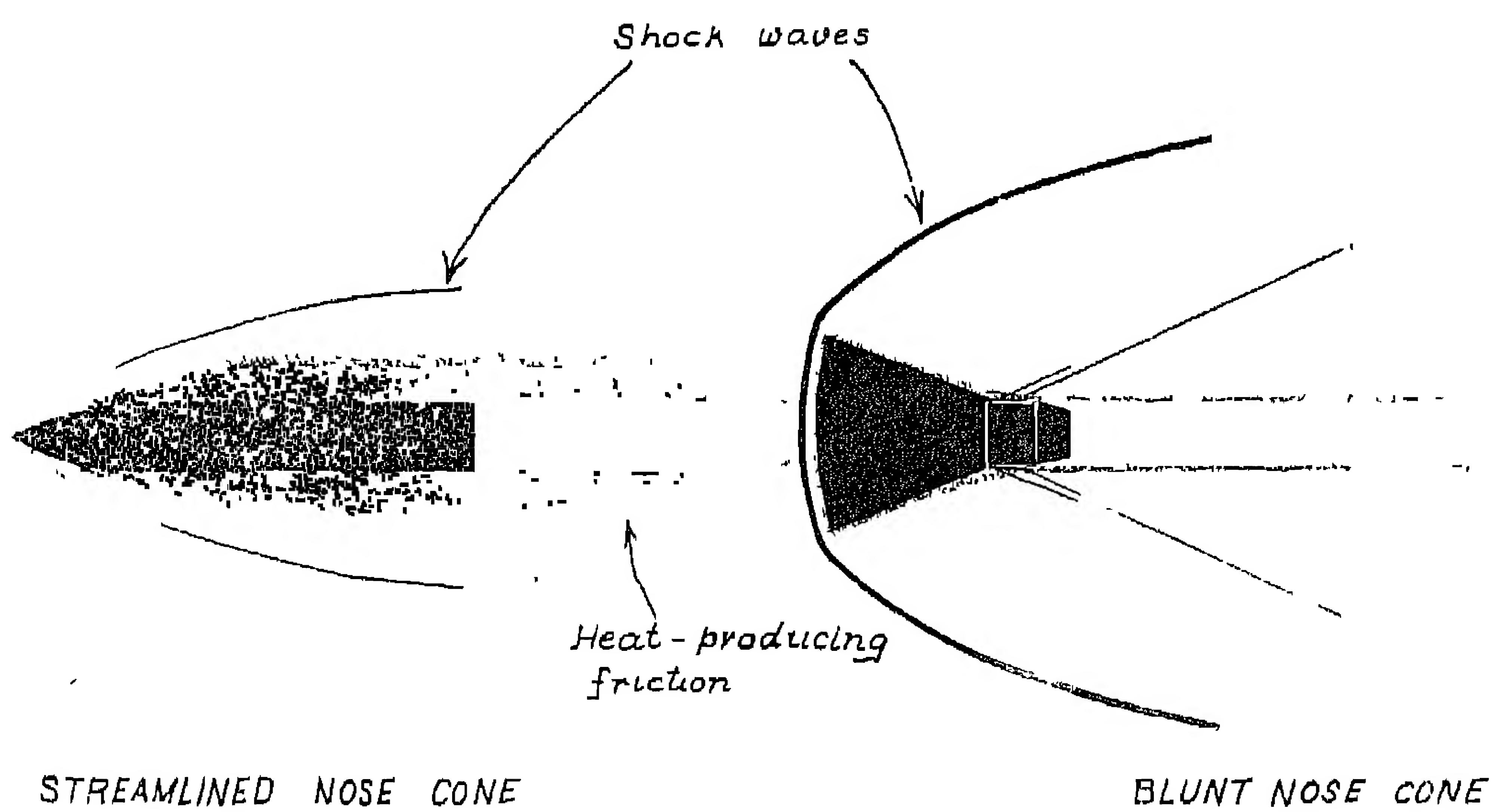

Fig. XIII. 61. Nose cone of a space capsule.

differences between a streamlined nose cone and a blunt nose cone.

Retro-rockets attached to the capsule can be fired at re-entry time to slow down the speed

A parachute which would act as a drag brake is possible to use. Drop a marble Then tie an identical marble in the centre of a handkerchief Hold this improvised 'parachute' by the corners, then drop it. Note the speed at which each falls. Try dropping them simultaneously from the same height.

Find a way to cool the space ship by use of water or liquids, either in front of or near the ship

Some may wish to study more about heat problems. Find out about *shock waves* (the compression of air). These differ at supersonic and hypersonic speeds. There are many problems in space flight. The heat of re-entry is one of many.

Read about controlled glide as a way to approach a planet like Earth.

3. Read about the experiments being carried on today to solve the problems of re-entry. Keep a scrapbook of articles, pictures, and your own ideas. In this way you can keep your knowledge up-to-date.

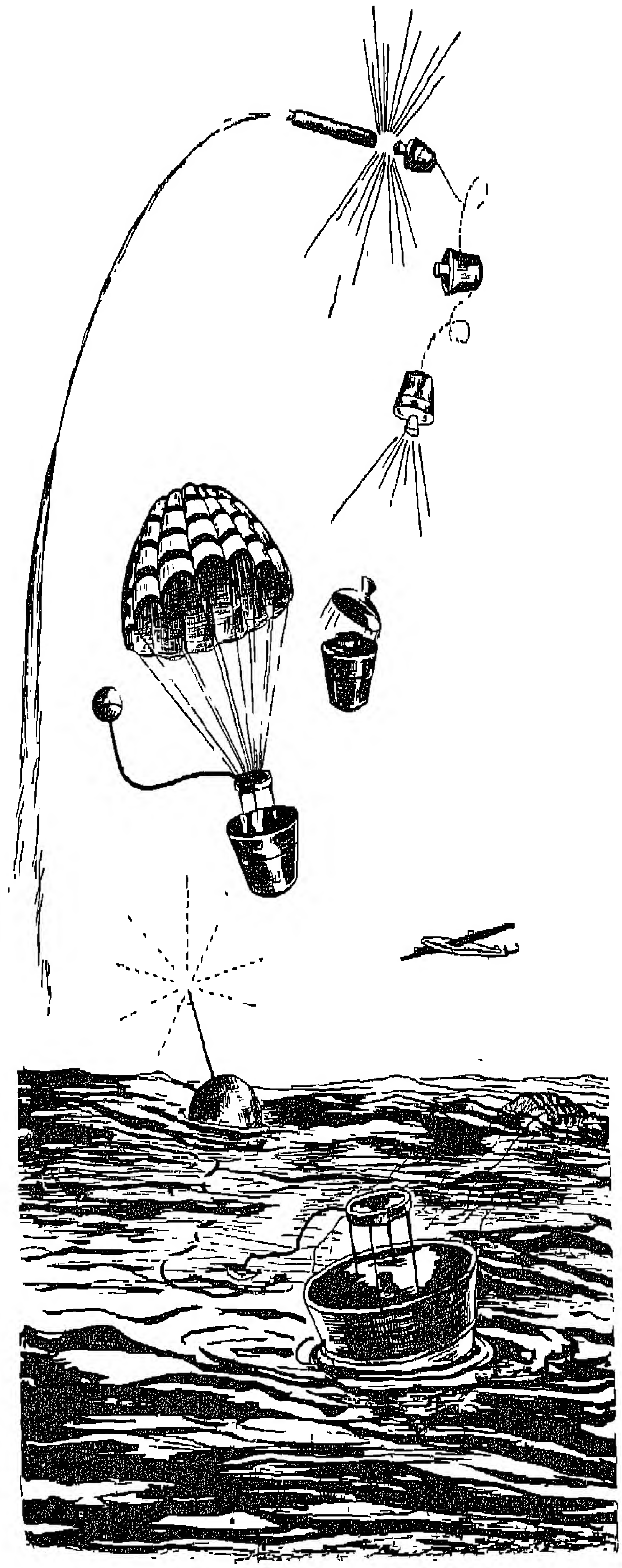

Fig. XIII. 62. Route of an artificial satellite returning to earth from space.

TABLE XIII 5 SPACE-AGE GUIDE TO THE PLANETS

Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Distance from the sun (millions of miles.)	36.0	67.2	92.9	141.5	483.9	886.0	1783.0	2791.7	3670.0
Theoretical minimum time to reach planet from Earth	83 days	45 days		58 days	1 year 8 months	3 years 5 months	7 years 5 months	12 years 2 months	12 years 2 months
Diameter (miles)	3,100	7,700	7,927	4,200	85,750	71,150	32,000	27,600	3,700
Time to complete one orbital revolution around the sun (measured in earth time)	88 days	225 days	365.25 days	687 days	11 years 314 days	29 years 168 days	84 years 7 days	164 years 285 days	248 years 146 days
Length of day (measured in earth time)	88 days	225 days	23 hours 56 mts	24 hours 37 mts	9 hours 50 mts	10 hours 14 mts.	10 hours 49 mts	15 hours 10 mts.	16 hours
Surface gravity (measured in terms of 1 g on earth)	0.35	0.88	1.00	0.38	2.64	1.17	0.92	1.40	0.16
Weight of a man on the planet if he weighed 200 pounds on earth	70	176	200	76	528	234	184	280	32
Escape velocity (miles per hours)	9,700	23,000	25,000	11,500	133,220	79,200	49,320	57,600	22,000
Temperature on surface	—460°F to 780°F	—4°F to 140°F	—90°F to 136°F	—130°F to 85°F	—215°F average	—240°F average	—300°F average	—330°F average	—345°F average
Number of moons	0	0	1	2	12	9	5	2	0

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COHEN. *The Birth of a New Physics*

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Basic Equipment and Supplies

The following is a list of essential equipment, supplies and tools that a science teacher of grade VI to VIII will need to carry out the activities listed in this book It should be possible to procure many of these articles either from the local market or by improvisation or from local junk yards or through collections by children from their homes and other sources.

EQUIPMENT

To be purchased from scientific supply houses

aquarium tank
ammeter
aneroid barometer
bell jar
beakers—(half a dozen, heat proof, 400 cc)
condenser, variable condenser (from a radio supply co.)
deflagrating spoon
dissecting needles, one set
dry cells—6, $1\frac{1}{2}$ volts
electromagnet
galvanometer
germanium diode (from a radio supply co.)
glass tubing (different bores)
laboratory flasks (heat proof, 500 cc.)
litmus paper
lenses (convex, concave)
light meter
magneto (generator)
microscope
microscope slides and cover glasses
metal crucible
magnets (2 bar, 1 horseshoe)
petri dishes (6)
photo-electric cell
prisms
rubber and plastic tubing (different diameters)
ring stand
storage battery
specimen tubes with corks
test tubes—(18×150 mm.)
thistle funnel
tuning forks (different pitch)
thermometer; laboratory, clinical, weather
watch glasses (half a dozen)
voltaic cell
voltmeter
y-tube (glass or metal)

To be purchased locally

bicycle pump
coloured chalk
clinical thermometers—2
compass, magnetic
electric light with long cord
electric bulbs (new) (difft. wattages)
electric doorbell (2) (buzzer)
funnel
glass panes
glass beads
gelatin
garden hose
jug
lamp chimneys
metre stick
measuring cups or jars (two)
mesh wire
metal tongs
metal foil
net, insect collecting
nozzle (for hose)
pans for water
pots for plants
protractor
rubber sink stoppers
resistors (filaments for electric heaters)
steel rule
syringe
scissors
plumbers' force cups

spring (coil)
shop-keeper's balance
source of heat, as hot plate, spirit lamp, etc.
thermos flasks
tin shears
torch light (2); also extra bulbs and cells
tinker toys (for building models)
wire; insulated, nichrome, etc.

To be purchased from the local junk yard or repair shop

bits of lead
copper, brass, iron filings (also zinc shavings)
cotter pins
old automobile, generator, induction coil, spark coil
old electric fan
old dry cells
telephone receiver or headphones
transformer, small

Simple tools (to be purchased locally)

adjustable wrench
brace and bits
claw hammer
files, triangular and flat
hand drill
knife
pliers, common and electrician's
saw (carpenter's; hacksaw)
scissors
screwdrivers
tape measure
tin snippers
trowel
wedge or chisel
vise

Certain useful references

animal bones (vertebrae and skulls, especially)
globe
geologic time table (chart)
models or pictures of poisonous and non-poisonous snakes
model of human ear
model of human eye
model of human heart
pictures of geologic formations
periodic table of the atoms
star almanac
star map
samples of rocks and minerals
world map
wind map of world

Household Items

balls: rubber, pingpong, tennis, etc.; old and new
balloons
boxes, shoe, cardboard, plastic pill, cigar
cardboard, corrugated, light-weight, white
coloured crayons
coloured yarn
cloth; flannel, cotton (bright colours, black, white) muslin, white cotton strips for first aid practice.
comb, plastic
cotton wool
candles (2 dozens, partly used ones)
corks and rubber stoppers (assorted sizes, 1- and 2-holed)
epsom salts
elastic bands
electric bulbs: new; different wattages
glass panes (different thicknesses), bakelite
grease, oil, vaseline
glue
gramophone records (old)
knife (pen-knife or paring knife)
jars and bottles; all shapes and sizes, some wide-mouthed, some narrow-necked, medicine bottles, gas jars, ink bottles.
marbles (at least 50)
mirrors, plane
metal sheets (copper, brass, aluminium, etc.)
metal scraps (all sizes and shapes)
molasses or sugar
paper bags
plastic bags; bits of rubber and plastic
paper: blotting, tissue, coloured construction, drawing, old newspaper, cellophane (coloured), black, white
pots for plants
seeds of small plants; bean
soap; shaving
steel wool
string, different sizes and strengths
tin cans: all sizes and shapes; also tops and

bottoms, several dalda cans
vinegar
wood: boards, scraps, sticks, bamboo; fibre-board, blocks.

Chemicals

acetic acid
agar agar, shreds
alum powder
anhydrous copper sulphate
antimony sulphide
asbestos (flexible)
blue vitriol (copper sulphate)
calcium chloride
carbon disulphide
calcium nitrate $Ca(NO_3)_2$
carmine stain, eosin dye
glycerol
hydrochloric acid
lime, slaked
limestone
magnesium ribbon
magnesium nitrate $MgSO_4$
manganese dioxide (powdered)
mercuric or lead oxide
mineral salts (some) in compounds of nitrogen, phosphorus
nitric acid
penicillin powder
phenolphthalein
phosphorus
potassium
potassium acid phosphate KH_2PO_4
potassium chlorate (powdered)
potassium nitrate KNO_3
potassium permanganate solution
sulphur
sulphuric acid
sodium metal
,, bicarbonate (baking)
,, peroxide
,, sulphate
,, hydroxide (lye)
,, chloride (salt)
red phosphorus
red lead
iron phosphate ($FePO_4$)

Paints

aluminium paint
plastic paint
varnish

Glossary

ACID: A substance, sour in taste that turns blue litmus paper red. (VII)

AGGLUTININ: A substance in the blood which causes certain other blood substances to clump or form a thickened mass, called a *clot* (III)

ALBUMEN The white of egg which consists mostly of the protein, albumin. (X)

ALGAE: Plural of 'alga'. A large group of green plants without definite roots, stems or leaves (VIII)

ALLOY: A metal which is composed of two or more metallic elements mixed together (I)

ALKALINE: Having the characteristics of an alkali, a substance that turns red litmus paper blue. (VII)

ALLUVIAL FAN: A fan-shaped deposit of soils and rocks deposited by a stream where it issues from a gorge onto more level ground. (II, VII)

ALMANAC: A calendar or table giving days, weeks, months and information about weather, sun, moon and stars during those periods. (XIII)

ALTERNATING CURRENT: A current of electricity in which the flow of electrons moves back and forth. (VI)

ALTIMETER An instrument in aeroplanes which measures air pressure and indicates the height of the plane above sea-level. (I)

ALVEOLI: Tiny air sacs in the lungs. (III)

AMPERE. The unit used to measure the quantity of electricity flowing in a circuit. (VI)

AMPLITUDE-MODULATION: A method of broadcasting radio waves in which the strength of the carrier wave is varied in amplitude by combining it with an audio signal. (VI)

AMPHIBIAN: Animal that lives both on land and in water. (X)

ANALYSIS: Separation of a substance into its parts, as separation of a mixture into the compounds of which it is made. (VII)

ANEMOMETER: An instrument that measures wind velocity. (I)

ANEROID BAROMETER An instrument that measures atmospheric pressure by means of a metal box containing a partial vacuum (I)

ANHYDROUS. Containing no water. (VII)

ANODE The positive pole in the electric cell or tube. (VII)

ANTENNA: A conductor for transmitting and receiving radio waves, also, one of the feelers on the head of an insect (XI, X)

ANTERIOR: Head or front end (e.g of an animal). (X)

ANTHRAX: A disease of cattle and sheep which may be transmitted to men. Anthrax was the first disease definitely found to be caused by bacteria. (XI)

ANTIBODY. A substance in blood plasma which acts against a specific type of disease germ or toxin. (III)

ANTIBIOTIC. Substances formed by some moulds and bacteria that destroy or prevent the growth of germs. (XI)

ANTITOXINS: An antibody which works against the toxins of a disease (III)

ANTI-VENIN: A substance injected into the blood to treat snake bite. (IV)

ARTIFICIAL RESPIRATION: A method of helping a person to breathe until his own body begins to breathe by itself. This can be done by a person with or without a machine. (IV)

ASBESTOS: A mineral that does not burn and is a poor conductor of heat (V)

ASPHYXIA: Suffocation or unconscious condition caused by lack of oxygen and excess of carbon dioxide in the blood. (VIII)

ASTEROIDS: Tiny planets that travel in orbits around the sun. In our solar system thousands of these are found, particularly between Mars and Jupiter. (XIII)

ASTRONOMY: The science of the sun, moon, planets, stars and other heavenly bodies. (XIII)

ATMOSPHERE: The air that surrounds the earth. (I)

ATMOSPHERIC PRESSURE: Air has weight and so the air that surrounds the earth, the atmosphere, exerts pressure. We call this atmospheric pressure. (I)

ATOMIC NUMBER: The number of an element in the Periodic Table equal to the number of protons in the nuclei of its atoms (VI)

ATOMIC REACTOR: A nuclear furnace in which chain reaction produces a great number of free neutrons and energy. (VII)

AURICLES: The two upper chambers of the heart that receive blood from the veins of the body and the lungs. (III)

AUTONOMIC: A division of the nervous system which regulates the vital internal organs in an involuntary manner (III)

AXIS: An imaginary or real line that passes through an object and about which an object turns or seems to turn. (XIII)

BAROGRAPH: An instrument for measuring and recording changes in atmospheric pressure. (I)

BASALT: A dark, granular igneous rock (II)

BATTERY: A group of two or more electrical cells connected together. (VII)

BAUXITE: A clay-like material that is the principal ore of aluminium. (VII)

BEAUFORT SCALE: A system of estimating wind speeds based upon the effects produced. (I)

BLADDER: A thin-walled sac in animals that holds urine. (III)

BLOOD TRANSFUSION: Transfer of blood from one person or animal to another (III)

BRACHIOPODS: Small marine shellfish abundant in Palaeozoic seas. Also known as 'lamp-shells' (VIII)

BRONCHUS (BRONCHII, plural): A division of the lower end of the trachae (wind pipe), leading to the lung. (III)

BUDDING: Form of reproduction in plants such as yeast, in which cells under certain conditions push out buds which become new plants.

Also, the process by which fruit growers, rather than depend on seeds, often graft buds or scions to a parent tree and so start a new growth. (VIII)

CAISSON: A large water-tight box or chamber for under-water construction of piers, foundations, tunnels, and the like. (I)

CALIBRATE: To check the scale of a measuring instrument by comparison with a standard instrument. (I)

CALIPERS: Instrument used to measure the diameter or thickness of an object. (III)

CALYX: The collective name for the sepals of a flower. (IX)

CAPILLARY ACTION: The property of a liquid which causes it to rise up very narrow tubes or spaces. (II)

CARBON MONOXIDE: A colourless, odourless, and very poisonous gas, formed when carbon burns with an insufficient supply of air, as in exhaust gases of automobiles. (IV)

CARRIER WAVE: The radio signal used to carry an audio signal through space. (VI)

CATALYSIS: The causing or speeding up of a chemical reaction by the presence of a substance that itself is not permanently changed. (VII)

CATHODE: The negative pole in an electric cell or battery. (VII)

CELESTIAL: Having to do with the sky or heavens. (XIII)

CELLULAR CIRCULATION. In the northern hemisphere, winds moving north from the Equator settle down at the horse latitudes and blow toward the east along the surface of the earth in a circular or cellular pattern. The winds of the Westerlies and Polar Easterlies circulate in a less defined cellular pattern. (I)

CELLULOSE: The principal part of the cell wall in most plants A complex carbohydrate (VII, IX)

CENTIGRADE THERMOMETER: A thermometer which has 0° for the temperature at which ice melts and 100° for the boiling temperature of water. (I)

CESS POOL: A pool or pit into which house drains empty, usually an insanitary arrangement (V)

CHAIN REACTION: A series of events, as in in the atomic bomb, where the energy released in the first step brings about the next, and succeeding steps. (VI)

CHAIN STITCH: Kind of sewing or stitching in which each stitch makes a loop through which the next stitch is taken. (XI)

CHEMICAL CHANGE An alteration of a substance or substances into a new substance or substances having different basic properties and identity from the original. (VIII)

CHROMOSOMES: Thread-like material found in the nucleus of the cell containing the genes which are responsible for the development of traits or characteristics of an individual. (VIII)

CHLOROPLASTS: Small bodies of cytoplasm, containing chlorophyll, that occur in the cells of green leaves and other green parts of plants. (VIII, IX)

CIRCUMPOLAR CONSTELLATIONS: The constellations which appear to go around the north and south poles of the heavens and which never set. (e.g Great Bear.) (XIII)

CISTERN: A reservoir or tank for storing water. (V)

CLEAVE: To split or divide; some minerals split with smooth faces and definite angles when struck (II)

COMBUSTION: Chemical process commonly accompanied by the production of heat, or heat and light (III, VII)

COMET: A member of the solar system, consisting of a bright head made up of an enormous group of rocks, and a tail made up of large quantities of dust and gas. (XIII)

COMPONENTS: Parts that compose something. (e g. A chemist can separate a chemical into its components.) (XIII)

COMPOUND. A substance that is formed of two or more elements chemically united in a definite proportion. (VII)

COMPUTE: To find an answer by mathematical work (XIII)

CONDENSATION. The process of becoming denser or more compact Cooled water vapour in the air condenses into clouds, and may condense further into rain drops. (I)

CONDENSER A device in which an electric charge can be temporarily stored. (VI)

CONDUCTOR: A substance, such as a metal, through which heat or electricity readily passes. (XI, VII, I, VI)

CONGLOMERATE: Rock consisting of rounded pebbles, held together by a cementing sand material. (II)

CONJUGATION TUBE: A connecting tube through which a gamete moves in the direction of other gametes. (VIII)

CONSTELLATION: A named group of stars that form a pattern in the sky. (XIII)

CONTOUR: Outline of a hill or valley; used here in contour ploughing, the following of natural ridges and furrows to avoid erosion. (II)

COORDINATE: Any of two or more magnitudes that define the position of a point, line, or plane by reference to a fixed figure or system of lines (XIII)

COROLLA: A collective term for the petals of a flower, taken as a unit. (IX)

CRANIAL: Having to do with the skull; (e g, cranial nerves). (III)

CRYOLITE: A mineral used in the process of making aluminium (VII)

CULTURE MEDIUM: A nutrient mixture used for growing algae bacteria, moulds and other living things. (V, III, IX)

CYTOPLASM: All the protoplasm lying outside the nucleus of a cell (VIII)

DEFLAGRATING SPOON. Spoon, used by chemists, in which materials are burned. (VII)

DNA (Deoxyribo nucleic acid): A class of nucleic acids which is the hereditary material of living cells The molecule is a long, ladder-shaped, double spiral structure.

DEPOSITION: Used here in the study of geology, as the process of building up sediments by various agents such as waves, winds, glaciers, etc. (II)

DETERGENT: A substance used in water for cleansing. (I, VII)

DEXTROSE. A sugar less sweet than cane sugar. (III)

DIATOMS Microscopic unicellular algae, floating in water with two overlapping halves of walls made of silica and ornamented in several ways. (II)

DIFFUSION The process by which substances become mixed together as a result of the movement of their molecules, also the scattering of light by a rough surface. (III)

DIRECT CURRENT: A current of electricity in which the electrons flow in one direction only. (VI)

DOLOMITE: A crystalline rock consisting mainly of calcium and magnesium carbonate (II, VII)

DOMINANT: One of a pair of contrasting inheritable character which shows up in the offspring, masking the effect of the other character (recessive). (VIII)

EFFERVESCE: To give off tubes of gas. (VII, II)

ELECTRIC ENERGY: The energy of electric charges or of electrons moving through matter. (VI)

ELECTRODE: The positive (anode) or negative (cathode) terminal in an electric circuit (VII)

ELECTROLYSIS The breaking up of a compound (liquid) into its elements by the passing of an electric current (VII)

ELECTROMAGNET An iron core round which is wound insulated wire, that becomes magnetized when an electric current flows through the wire (VI)

ELECTROMAGNETIC ENERGY. Waves of energy given off by electrons moving from one energy level to another in an atom (VI)

ELECTROMOTIVE FORCE The pressure, measured as the voltage, of an electric current (I)

ELECTRONS. Atomic particles which move around the nucleus of an atom and carry a negative charge (VI)

ELECTRON TUBE: A vacuum tube in which electrons flow from a cathode to a positively charged plate (VI)

ELECTROPLATING. A process in which a thin film of metal is deposited on an object by an electric current. (VII)

ELECTROSCOPE A device used to detect the presence and intensity of an electric charge (VI)

ELECTROSTATIC ENERGY: The energy possessed by an electric charge. (VI)

ELEMENT. The simplest form of matter that cannot be broken down into other substances by ordinary means. (II, VII)

ELEVATOR: Thing that raises or lifts up. It is commonly called a '*lift*'. (XIII)

ELLIPSE: Oval having like ends. It is the path of a point that moves so that the sum of its distances from two fixed points remains the same. (XIII)

EMBRYO: A young developing organism. (X)

ENERGY: The ability to do work. (VI)

EOSIN: Red dye-stuff used in microscopic work and colour photography. (VIII)

EPILEPSY: A nervous disease in which the afflicted person has moments of unconsciousness, sometimes with convulsions. (IV)

EQUATORIAL: Of, at or near the equator (XIII)

EROSION: A gradual wearing away of soil and rocks by glaciers, running water, waves or wind. It is a grinding action with abrasive material being moved. (II)

ESCAPE VELOCITY: Minimum velocity which will enable an object to escape from the surface of a planet or other body, as the escape velocity of the Earth is just over seven miles per second or 25,000 mph. (VI)

EXCAVATION. A digging out or up. (XIII)

EXCRETION: (excretory—adjective) the process by which waste materials are removed from living cells or from the body. These waste materials are called *excreta*. (III, IV)

EXHALATION. Breathing out. (IV)

FAHRENHEIT: A thermometer that has 32° for the freezing point of ice and 212° for the boiling temperature of water. (I)

FALL-OUT: Radioactive dust carried into the upper atmosphere following an atomic explosion, and later brought down by rain. (VI)

FELDSPAR. A relatively hard crystalline mineral composed mostly of sodium or potassium aluminium silicates. (VII)

FERMENTATION: A process by which organic substance is broken down by living organisms in the absence of oxygen. (VII)

FERTILIZATION: The union of one gamete with another, an essential feature of sexual reproduction. (IX)

FILTER: Device for straining out substances from a liquid or gas by passing it slowly through felt, paper, sand, charcoal, etc. (V)

FIBROUS. Containing thread-like structures called fibres. (IX)

FLAGELLUM: A long whip-like part, which is an organ of locomotion in certain cells, bacteria, protozoa, etc.

FLASHLIGHT. An electric torch. (VI)

FLUSH TANK A storage tank from which water can flow rapidly when flushing a toilet. (V)

FOLIOSE: Thin or leaf-like. (II)

FOSSIL The remains or traces of animals or plants of a former age. (VIII, XIII)

FRACTURE. Break, crack (II, IV)

FREQUENCY: Rate of occurrence, for example, electric power alternates 100 times per second hence is called 50 cycle current (VI)

FREQUENCY-MODULATION: A method of broadcasting radio waves in which the carrier wave is varied in frequency by combining it with an audio signal. (VI)

FRICTION The resistance to movement as one object moves over or through another. (VII)

FRONT: The boundary between two adjacent air masses. (I)

FULCRUM: Support on which a lever turns. (I)

FUNGICIDE: Any substance that kills fungi. (II)

GALAXY: A large group of many millions of stars. The galaxy in which our solar system is located is called the Milky-Way. (XIII)

GAMETE: A sex cell capable of uniting with another to form fertilized cell that can develop into a new plant or animal. (VIII)

GANGLIA: Mass of nerve cells lying outside the central nervous system (III)

GLOBULAR: Spherical or ball-shaped. (XIII)

GYPSUM. Gypsum is a mineral, a compound of calcium, sulphur, oxygen and water Its principal use is as a source of plaster of Paris which is made by heating gypsum to drive off most of its water (VII)

GASTROPODS: Stomach-footed animals, as for example, slugs and snails. (VIII)

GEOLOGY: The science that deals with the earth, the layers of which it is made, and their history. (XIII)

GERMICIDE: A substance that kills germs. (V)

GLACIER Repeated thawing and freezing of the snow in snow fields that never completely melts, forms ice which eventually moves and becomes a river of ice, a glacier. (II)

HARROW: To pulverize the soil with a spike-toothed instrument or disc called a harrow (IX)

HI FI (record player) High Fidelity: The reproduction of sound very near in quality to the original. (XI)

HILUM: The scar on a seed coat marking the place of attachment of the seed stalk to the seed (VIII)

HORSE LATITUDES: Either of two regions of the earth characterized by high pressure, calms, and light winds. Located at about 30°N and 30°S (I)

HUMIDITY: The grammes of water vapour present in 1 cubic metre of air is called the absolute humidity. The ratio of the quantity of water vapour actually present in any volume of air to the total quantity that same volume of air could hold at that same temperature, is called the relative humidity.

HYBRID: An offspring from a cross between parents differing in one or more traits. (VIII) (IX)

HYDROGENATE: The process of combining a substance with hydrogen, as in the case of a vegetable oil or fat. (VII)

HYGROMETER: An instrument for measuring the relative humidity in the air (I)

HYPOCOTYL: That part of a plant embryo from whose lower end the root develops. (VIII).

IGNEOUS ROCKS. Those formed as a result of the action of heat within the earth. They are rocks formed from liquid lava. (II)

IGNITION POINT: The temperature at which a particular substance will catch fire and burn (VII)

INDUCED CURRENT: A current of electricity produced when a conductor cuts across magnetic lines of force (VI)

INOCULATION: An injection into the body to produce immunity or to help overcome a specific disease. (III)

INSECTICIDE: A chemical used to destroy (kill) insects. (IX)

INSPIRATION: The intake (or breathing in) of air into the lungs. (IV)

INSULATION: A material for retarding or preventing the transfer of heat, sound or electricity. (IV, V, VII)

INTERFEROMETER: An instrument which by means of a system of mirrors and glass plates separates light in such a way that its wave length, refraction indices and other characteristics can be studied precisely. (XI)

INTERNAL COMBUSTION ENGINE: An engine in which fuel is burnt inside the cylinders of the engine. (VI)

INTERNATIONAL GEOPHYSICAL YEAR (IGY): An 18-month period in 1957 and 1958 during which scientists from many nations conducted an intensive study of the earth and its environment. (II)

INVOLUNTARY ACT: An act not beginning or controlled by the will or higher centres of the brain. (III)

IONOSPHERE: A region of ionized air beginning about 65 miles above the earth (I)

JET PROPULSION: A forward thrust produced by the discharge of a high-speed stream of hot gases. (VI)

KAOLIN A fine often white clay with industrial and medical uses. It results from extreme weathering of minerals such as feldspar. (VII)

KINETIC ENERGY: The energy of matter in motion. (VI)

LARVA The stage which follows the egg in the development of certain animals. (III)

LEACHING The process by which materials are dissolved out of another material by water or another liquid passing through Thus soils are leached by ground water. (II)

LEGUMES, LEGUMINOUS A family of plants that have bacteria in their roots which are capable of fixing the nitrogen of the air (VIII) (IX)

LEUCOCYTES A type of cell found in the human blood. It functions in the healing of injury and infection, often acting as a phagocyte (III)

LIGAMENTS. Strong, tough bands of tissue which hold the movable joints of the body together (IV)

LIGATURE · Band or cord used in tying up a bleeding artery (V)

LIMONITE · Mineral formed by iron, oxygen and water. It is an important iron ore. Brown rust is limonite (VII)

LINES OF FORCE Invisible magnetic forces curving through space from one pole of a magnet to another. (VI)

LITMUS: An organic substance used as an indicator, turning red for acids and blue for bases (VII)

LITTER The offspring of an animal at one birth. (VIII)

LUBRICATION. The process of oiling a machine or vehicle so that the parts work together more smoothly and with less wear than if not lubricated. (IV)

LUGOL'S SOLUTION. A deep brown solution of water, potassium iodide and iodine used as a disinfectant The proportions are approximately 10 grammes of potassium iodide and 5 grammes of iodine in 100 millitres of water. (IV)

LUSTER · The glossy appearance or shine of a material surface. (II)

LYMPH · A fluid derived from the blood plasma which enters the tissue spaces and lymph vessels (III)

MACRONUTRIENT: A chemical (mineral) element needed in relatively large quantities by a plant for proper growth to take place.

(Examples · potassium, calcium, magnesium, nitrogen, phosphorus, sulphur) (II)

MACH The speed at which sound travels. (XIII)

MAGNETIC FIELD · The space acted upon by magnetic forces (VI)

MAGNETIC POLE · One of the two points of the earth toward which the end of a compass needle is attracted (VI)

MAGNETISM: The property of certain substances which causes them to attract iron, nickel, and other metals These are known as magnets (VI)

MALACHITE A green mineral used for ornamental articles (VII)

MARINER'S COMPASS: A type of compass used in navigation with two or more parallel magnetic needles or bundles of needles It is enclosed in a glass container and permanently installed on the ship's deck in a special box. (VI)

MARROW: The soft, spongy tissue which fills the cavities of most bones. The red blood cells are formed in the marrow. (III)

METAMORPHIC ROCK: A rock changed by heat and pressure into a harder, more highly crystallized form of rock. (II)

METEORS: Bits of rock that speed through our atmosphere from outer space. The friction developed by their speed through the earth's atmosphere causes them to heat up and glow Meteors usually burn out before they reach the earth (XIII)

METEORITES. A meteor that reaches the earth's surface. (VII)

METHYLENE BLUE: A basic dye used as a biological stain, to aid in the preparation of microscope slides. (VIII)

MICRONUTRIENTS. Required as food by plant or animal in minute amounts (compare with macronutrients.) (II)

MICROORGANISM. A living thing too small to be seen except with a microscope. (VIII)

MICROPYLE. The opening in the ovule wall through which the pollen tube enters. (VIII)

MILKY WAY. A faint band of light stretching across the sky; composed of a vast number of stars. Our universe is in this galaxy. (XIII)

MIXTURE: Two or more substances put together in such a way that each retains its individual properties. The substances in a mixture can be separated by simple methods (VII)

MOH'S SCALE: A scale of hardness for minerals ranging from 1 for the softest (talc) to 10 for the hardest (diamond). (II)

MOLECULE: The smallest part of a substance that can exist and still retain the composition and properties of the substance. (VII) (XIII)

MOLTEN: Describes a substance which has been heated until it is in a liquid state. (II)

MOMENTUM. The mass of a substance multiplied by its velocity. (VI)

MONSOON: Wind that changes its direction with a change of season, particularly in Asia. (VII)

MUSCOVITE: A colourless or pale brown mineral consisting of a potassium mica of variable composition. (VII)

NADIR: The point on the celestial sphere directly beneath the observer; the lowest point on the sphere with altitude—90° (XIII)

NEBULAE: Vast masses of dust and gases in space. Galaxies outside our own Milky Way are also sometimes called nebulae. (XIII) (singular nebula)

NEUTRONS: Atomic particles found in the nucleus of an atom and which do not carry an electric charge. (VI)

NITROGEN FIXING BACTERIA. Bacteria that combine the nitrogen of the air with other elements, forming a nitrogen compound that can be used by plants. (IX)

NITROGENOUS WASTES Body wastes containing nitrogen (III)

NUGGET: A naturally formed lump of a precious metal. (VII)

NUCLEAR ENERGY. A form of potential energy produced by the breakdown of unstable atomic nuclei. (VI)

NUCLEAR FISSION. The breaking apart of the nucleus of a heavy element into lighter nuclei of different elements with a release of energy (VI)

NUCLEAR FUSION. The joining together of light nuclei of elements to form a heavier element with a release of energy. (VI)

NUCLEUS. The dense part of an atom composed mainly of protons and neutrons. (VI) The central material in a cell that controls most of the activities of the cell. (VIII)

OBSERVATORY A building or place equipped for observation of natural phenomena (usually astronomical) (XIII)

OBSIDIAN A volcanic glass, generally black in colour (II)

OHM: The unit used to measure the electrical resistance to the flow of a current in a conductor. (VI)

ORBIT. Path of a revolving object, like that of the earth around the sun. (XIII)

ORGANIC (matter). Of, or pertaining to living things. (V)

OSMOSIS. Process by which liquids move through membranes. (IX)

OXIDE: A compound consisting of two elements one of which is oxygen. (VIII)

OXIDATION: Oxidation is any reaction in which an atom, a group of atoms or an ion loses electrons. A common example of

oxidation is the combination of hydrogen with oxygen to form water

OXY-ACETYLENE TORCH : A welding torch which burns a mixture of acetylene and oxygen, resulting in a very hot flame (VII)

'PAYLOAD'. Weight of everything in a rocket or missile that can be called useful cargo, such as scientific instruments and supplies It is usually less than a tenth of the total weight of the rocket with full tanks of fuel. (VI)

PIPETTE A piece of equipment used in transferring and measuring liquids. Its simple form is a "dropper", a glass tube with a narrow end through which liquid is drawn by closing the upper end, often a rubber nipple (VIII)

PISTIL. The female organ of a flower in which the seeds later develop. (IX)

PLACENTUM · An absorbing structure which spreads over the inner membrane of the uterus. (X)

PLANET: Heavenly body that revolves in a regular orbit round the sun (XIII)

PLANETARIUM: A domed-shaped room or building on which spots of light are projected to represent various astronomical events; as the night time sky. (XIII)

PLANETOIDS (See ASTEROIDS).

PLASMA · A clear, almost colourless liquid which makes up the fluid part of the blood. (III)

PLATELETS. Small round discs in blood which help it to clot. (III)

PLINTH. A solid block serving as the foundation base of a building. (V)

PLUMULE That part of a plant embryo from which the shoot develops. (VIII)

POLLEN The fine, yellowish powder from stamens consisting of cells necessary for fertilization of the ovules. (IX)

POLLINATION: Transfer of pollen from the stamens to the pistils of flowers. (IX)

POLLUTED WATER Unclean or impure water (V)

POSTERIOR · The rear or back end of an animal. (X)

POTENTIAL ENERGY: The energy stored in matter or the energy of position. (VI)

POWER. The rate of speed with which work is done (VI)

PRECAMBRIAN. Time preceding the Cambrian era such as the Archaeozoic and Proterozoic eras. (XIII)

PRECIPITATE: A substance in a solid state which has been separated from a solution due to a physical or chemical change. (II)

PRECIPITATION. Rain, snow, hail, sleet, drizzle etc (I)

PRIMARY COIL: A coil of wire connected to a source of electric current. (VI)

PROPELLANT: The chemicals used to produce thrust in a rocket engine. (VI)

PROTONS: Atomic particles found in the nucleus of an atom and carrying a positive charge. (VI)

PROTOZOA: Small, simple, one-celled animals. (VIII)

PULVERIZE To reduce a substance as by grinding or crushing, to very small particles. (II)

PALAEONTOLOGIST: (see Palaeontology) · A scientist who studies pre-historic life and fossil remains. (XIII)

PARACHUTIST: A person trained and equipped to jump from an aeroplane, with the help of a parachute. (XIII)

PARAFFIN. A waxy crystalline substance that is white, translucent, odourless and tasteless. (VII)

PARALLEL CIRCUIT. A circuit that divides and includes alternative routes through which the electrical current flows. (VI)

PASTEURIZATION. Heating milk to 63°C for about one-half hour to kill the micro-organisms contained in it (XI)

PATENT: An official document granted by a government which gives certain privileges of monopoly to one who invents or discovers a new and useful process or product. (XI)

PEDIGREE: A record of a line of ancestors showing the purity of a breed (as of horses, dogs, or plant strains.) (VIII)

PERCOLATION: The process of liquid passing through a substance to extract its soluble parts. (II)

PERIPHERAL: Marginal. (III)

PHAGOCYTES: A body cell that surrounds and thus destroys foreign materials which enter the body and other body debris, such as dead cells. (III)

PHENOMENON: An event of experience or reality. (XIII)

PHOTOELECTRIC CELL: An electron tube which produces a flow of electrons when light strikes the cathode (VI)

PHOTOMETER: An instrument used to compare intensities of two light sources. (VI)

PHOTOSYNTHESIS: The process by which a green plant makes sugar and oxygen from carbondioxide and water, in the presence of light. (VII) (IX)

PHYSICAL CHANGE: A change in the size, shape, or state of a substance, but not in the structure of its molecules. (VII)

PHYSICS: The scientific study of the forms of energy and their effects on different materials (VI)

PIGMENT: A substance of plant and animal cells and tissues which gives them colour. (III)

RADIATION: The transmission of energy in the form of rays. Light is a form of radiant energy. (I)

RADIOACTIVITY: The uncontrolled breakdown of unstable nuclei of atoms which gives off high-energy particles and rays. (XIII)

RADIOSONDE: A radio transmitter attached to a balloon which carries weather instruments to high altitudes, records weather conditions and sends them to earth by radio signals. (I)

RADIO TELESCOPE: An instrument which catches radio impulses from stars. When an astronomer analyzes these impulses he can get some idea of what a star is made of (XI)

RADIO WAVES: Electromagnetic waves produced by high-frequency vibrations of electrons. These are similar to light waves, but of a lower frequency. (VI)

RAIN GAUGE: An instrument which measures the amount of rain, snow, sleet or hail that falls at a given time and place. (I)

RECEPTOR: The ending of a nerve fibre that is specialized to receive one particular type of stimulus (III)

RECESSIVE TRAIT: One of a pair of contrasting inheritable characteristics which does not show up in an offspring when the other dominant trait is present. (VIII)

REFLECTING TELESCOPE: A telescope in which the light is reflected from a large mirror at the base of the telescope to a lens, through which the observer looks (XI)

REFRACTING TELESCOPE: A telescope which has a lens at each end. Refracting means bending or turning (light rays) (XI)

RELATIVITY: A theory formulated by Albert Einstein regarding the relative motion of bodies and associated phenomena, and leading to the assertion of the equivalence of mass and energy. (XI)

REPRODUCTION: The process during which plants and animals produce new organisms of their kind. (VIII) (XIII)

RESISTANCE: The object or weight moved by a machine. The opposition to the flow of electrons in a conductor, or of fluids through a pipe. (V)

RESPIRATION: The process of breakdown of food substances (sugars, carbohydrates) by a living organism in which oxygen is taken in carbon dioxide is given off (IV)

ROCKET ENGINE: A heat engine that can operate beyond the earth's atmosphere (VI)

RODENT: A group of small mammals known for their sharp gnawing teeth (X)

ROTATION The turning about of a body on an axis or centre. (X or XIII)

SATELLITE. Small body revolving around a larger body. Example: the moon around the earth (XIII)

SECONDARY COIL A coil of wire in which a current of electricity is produced by changes of the current in the primary coil. (VI)

SEDIMENT: Applied to any layer of loose material, such as sand, mud or gravel, dumped by one of the agents of erosion. (V)

SEDIMENTARY ROCK Rock formed by deposits of sand silt or clay layers. (II) (VIII)

SEPALS. The outermost leaf-like parts of a flower. Sepals cover petals and other parts in the bud. (IX)

SEPTIC TANK. A tank for making sewage harmless by the action of anaerobic bacteria (V)

SERIES CIRCUIT: An electric circuit in which the current flows through each electrical connection in turn. (VI)

SERUM A substance which contains antibodies to help the body overcome an infection. (III)

SEWER: A ditch, drain, or underwater pipe to carry off household or industial waste matter water. Water drains are called storm sewers (V)

SEXTANT: An instrument used by navigators to measure angular distance. (XIII)

SEXUAL REPRODUCTION Reproduction involving two parents Sperm cell unites with an egg to produce a fertilized egg or zygote. This fertilized egg develops into an individual. (VIII)

SHALE: A sedimentary rock resulting from the consolidation of mud. (V)

SHIELDS. Scales on the heads of snakes. (X)

SHOCK WAVE: The layer of compressed air in front of a space vehicle whose velocity is between mach 1 and mach 5. (XIII)

SIDEREAL MONTH: The period of revolution of the moon with respect to the stars as seen from the earth, about $27\frac{1}{3}$ days. (XIII)

SHOCK. A body condition in which the vital processes do not function adequately. The symptoms are pallor, weak but rapid pulse, shallow respiration, nausea, mental upset or dullness and low blood pressure. Usually a result of severe injuries or major surgery (IV)

SILICA SILICON. A non-metallic element very common in the minerals of the earth's crust. Sand is mostly composed of a combination of silicon and oxygen (VII)

SIPHON: A tube bent to allow a liquid to pass over an intervening elevation to a lower level due to atmospheric pressure. (1) (V)

SLAG The waste material resulting from the combination of limestone and sandy impurities when ores are smelted. (VI)

SLATE. A fine-grained rock which breaks into thin, flat slabs, often used for roofs. It is formed from the compression of shales and clays (V)

SPECTROGRAM: A photograph, map or diagram of a spectrum (XI)

SPECTROGRAPH: A spectroscope equipped for photographing a spectrum. (XI)

SPECTROSCOPE: An instrument for analyzing the different colours in the light given off by a glowing object, such as star. Such analyses enable an astronomer to find out what elements are present in the object or star. (XIII)

SPECTRUM: The band of colours produced when white light is passed through a prism. A rainbow shows the colours of the spectrum. (XIII)

SPIRACLES: Tiny air-holes occurring in insects along either side of the abdomen and in the thorax wall. (X)

SPIROGYRA. A thread-like green alga common in ponds, floating as scum. (VIII)

SPLINT A stiff material (wood, metal) used to immobilize or restrict motion in a part of the body, usually in the treatment of a fracture (IV)

SPROCKET WHEEL: A wheel with cogs or sprockets to mesh with the links of a chain. (VI)

STAGNANT WATER: Water which stands still in a pond or depression over a long period of time. If polluted is dark in colour and has a foul smell (V)

STAMENS: The parts of a flower that contain the pollen, each stamen has a slender stalk and a box-like structure which contains the pollen. (IX)

STAINLESS STEEL: An alloy steel containing chromium which does not rust or corrode (VI)

STATIC ELECTRICITY: An electric charge on an insulator (VI)

STERILE: Clean; free from microorganisms and other living organisms. (IV)

STETHOSCOPE: An instrument used by doctors to listen to sounds inside the body, especially in the heart and lungs. (III)

STIMULANT (Tea, Coffee, Cocoa): A substance which causes a slight increase in body activities. (IV)

STOMA (Stomata Plural): Lens shaped openings on the surface of a leaf more on lower than on upper surface—also found on some stems. (IX)

STRATOSPHERE: The upper layer of our atmosphere where clouds never form and the temperature is relatively constant. It is located between the troposphere and the ionosphere. (I)

SUCTION CUP: A rubber cup in which a partial vacuum is produced when it is pressed against a surface. A small suction cup is used in treating snake bite to draw poisoned blood from the wound. (IV)

SURVEYOR: One who measures distances, land contours, heights of distant objects, etc., by applying the principles of geometry and trigonometry. (XIII)

SUSPENSION: Method by which mud and sand are carried in a stream between the surface and the bottom. (XI) (XIII)

SYNODIC MONTH The period of revolution of the moon with respect to the sun; the interval between consecutive new or full moons, about $29\frac{1}{2}$ days. (XIII)

SYNTHESIS: A combination of parts to form a whole (VII)

TALC A white or light-coloured, soft mineral with a soapy feel (VII)

TAP ROOT: The main root of a plant from which lateral roots arise; often this root is swollen due to accumulation of food in it (IX)

TEMPERA A type of water paint used by artists. (VIII)

TERRACING The checking of the flow of water on sloping land by building level areas to prevent soil erosion. (II)

THEORIES Explanations which attempt to account for the way something behaves, but which have not been definitely proved by scientific experimentation. (VI)

THERMOCOUPLE: A device for measuring temperature using two electrical conductors made of different metals (as copper and iron). (VI)

THERMOELECTRIC JUNCTION: A device made of two different metals which produces electricity when heated (VI)

THERMOSTAT: An automatic device which keeps the temperature of an enclosed space constant. (VI)

THRUST A force produced by the propellors or escaping gases in an aeroplane or rocket engine. (VI)

TOURNIQUET: A constricting band applied between wound and heart to control bleeding. (IV, X)

TRACHEA Tube leading to the lungs; the wind pipe (X)

TRADE WINDS: Winds that originate in the

horse latitudes and blow toward the doldrums. (I)

TRANSFORMER A device used to increase or decrease electrical voltage of an alternating current. (VI)

TRANSISTOR: A coined word for a semiconductor crystal that conducts both positive and negative charges in a current (VI)

TRANSPIRATION The way plants lose water by evaporation. (IX)

TRIANGULATION. A method of indirectly measuring distance by sighting the distant point from two points a known length apart. (XIII)

TROMBONE: A wind musical instrument with a cupped mouthpiece and a cylindrical metal tube bent upon itself The player can control the length of the vibrating air column by pushing and pulling a part of the tube. (VI)

TROPOSPHERE. The layer of the earth's atmosphere immediately above the crust, extends to a height of 5 to 10 miles. (I)

TUNING FORK: A two-pronged metal instrument that gives a fixed tone when struck It is useful for tuning musical instruments. (VI)

TURBINE ENGINE A machine in which expanding gases turn a *rotor* to produce motion.

TURGID The stiffness of plant cells due to the presence of plenty of water. (III)

UMBILICAL CORD: The cord that leads from the embryo to the placentum of a female mammal (X)

UNCONSCIOUSNESS A condition in which a person is not aware of sensations, feeling or thought (IV)

VACCINATION: A method of introducing into the blood stream a liquid called vaccine which builds up in the body an immunity to specific diseases (III)

VACUOLE: A cavity within the protoplasm containing a solution of sugars, salts, pigments, etc such as a food vacuole. (VIII)

VACUUM TUBE: A tube used to control the flow of electric current (XI)

VALVE: Any device for regulating the flow of a fluid in a pipe, chamber, or veins (III)

VEGETATIVE PROPAGATION: The multiplying of organisms by the simple device of dividing or breaking off its organs or parts, which later develop into new organisms. (IX)

VENTILATION The circulation of fresh air inside a building or enclosure (V)

VELOCITY The speed at which an object moves in a given direction combined with direction (I)

VENTRAL Refers to the belly side of an animal, side opposite to the back (X)

VENTRICLE One of the two lower chambers of the heart Ventricles receive blood from the upper chambers, or auricles, and pump it out into the arteries (III)

VERTEBRATE. A member of a group of animals which have internal skeletons The skeleton includes a jointed backbone or spine, a skull, and rib, leg, and arm bones. (XI)

VIRUSES: Things which are too small to be seen with an ordinary microscope. Viruses infect animals and plants causing diseases. (III)

VOLT The unit used to measure electrical pressure or electromotive force in a current. (VII)

WEATHERING: The crumbling of rock material by mechanical or chemical processes such as the following: mechanical processes of expansion and contraction, freezing and thawing, growth of plants, chemical processes of oxidation, carbonation, and hydration.

WEATHER STATION: A laboratory equipped with instruments to observe and record the weather (i.e.—the condition of the atmosphere at a given time and place) (I)

WINDS ALOFT: Winds flowing in the upper troposphere in contrast to winds flowing along the surface of the earth. (I)

WIND VANE: An instrument which indicates the direction from which the wind is flowing. (I)

WOMB (Uterus) Organ in which young offspring are nourished and developed until the time when they are born. (X)

WROUGHT IRON. A commercial form of iron containing little carbon. It is used for fences and gratings, and furniture, (VII)

YEAST A fungus which causes fermentation. It is a single celled organism which reproduces by a process called budding (VII)

ZENITH Point in the sky directly above the observer (XIII)

ZYGOTE. The fertilized egg cell in plants and animals (VIII)